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Air Washing as a Means of Obtaining Clean Air in Buildings

TESTS SHOWING POSSIBILITIES IN WASHING AND RECIRCULATING INDOOR AIR.

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and
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Clean air in motion and of proper temperature and humidity is necessary to indoor comfort. This is, perhaps, as succinct a statement as can be made of atmospheric requirements according to modern views.

Our concepts of ventilation are undergoing a change. Slight reductions in the amount of oxygen or slight increases in the amount of carbonic acid in the air we breathe are no longer feared. The human body can automatically adapt itself to slight changes in the proportion of these gases. It is more difficult for the body to adapt itself to temperature changes, and these may cause more or less discomfort and damage.

The heat relations of the body are complicated, involving heat production within the body, affected by food and by physical and mental exercise; heat transference within the body from the interior to the surface, and heat elimination at the surface, for human beings live normally in an atmosphere cooler than the body. Heat elimination is itself a complicated matter; it is lost by conduction, by convection, by radiation; it is affected by the temperature and humidity of the air, by the clothing worn, by the perspiration produced and evaporated. So complicated are these relations that we have not yet solved them. We do not yet know the best combination of indoor temperature and humidity for our greatest bodily comfort and efficiency.

We do know, however, as a matter of universal experience that it is uncomfortable to remain in air that is still, or, as we say, that is "dead." If the air that we exhale remains so near our faces that we re-breathe a considerable portion of it at each succeeding breath a feeling of oppression and discomfort ensues. Air stagnation also forms an atmospheric cloak about our bodies which affects their heat conditions. Mere stirring of air often changes discomfort to comparative comfort; witness the effect of the introduction of fans in the New York subway cars.

The benefits of sleeping in a cold room in which the warm exhaled air quickly rises so that the next breath is new air, and the benefits of outdoor sleeping are

due in great measure to the motion of the air. No system of ventilation can be regarded as satisfactory that does not cause a sufficient circulation of the air.

CLEAN AIR ESSENTIAL.

Another thing that we need to appreciate is that the air that we breathe should be clean. So anxious have we been in the past to make sure that the carbonic acid did not exceed some illogical, arbitrary standard that we have overlooked this most patent and obvious need. Of course, the extremes of this quality of cleanliness have been recognized. We know that people who work at dusty trades, in dust-laden air, sicken and die of diseases that gain a foothold in the lungs; and we send our sick to the mountains and the seashore and spend our vacations in the relatively clean air of the woods and fields and upon the waters.

Cleanliness is the great thing to be desired in air as it is in water. From time immemorial water that is grossly foul has been regarded as dangerous, but it is only within a generation or so that water which is only moderately contaminated has been regarded as dangerous. A clean water supply is now a watchword of our modern cities. If precedent is followed we shall come to regard as undesirable much of the air that would not by present day standards be called unclean, as well as air that is grossly laden with dust and foul gases.

Modern cities are dust producers. Streets and pavements, and even sidewalks, are worn by friction of the traffic, especially in this age of the railroad and automobile; car wheels are ground to metallic dust; fabrics turn to lint; fuel burns with products of smoke and ashes. Dust is being continually produced, both within and without our factories and houses.

DUST PARTICLES NEAR SIDEWALK VERY LARGE.

Recent studies made by us in several cities have shown that the number of dust particles in the air just above the sidewalks is very large, even on quiet days. At the air inlets of some of the commercial buildings in Boston the numbers of particles, as determined by microscopical counts, ranged from 100,000 to nearly 1,000,000 per cubic foot of air. With active wind movement the numbers are probably much higher, but even with the lesser number mentioned the number of particles inhaled by a person in an hour would be a million and a half. To be sure, the particles making up this vast number are very tiny, ranging from 0.5 to 15 microns in diameter, with an average of about 3 microns (0.003 millimeter), and their combined bulk is not large.

Air contains more dust near the street level than at higher elevations. Tests made on May 13, 1913, at the South Terminal Station, Boston, where air is taken in at the roof, showed lower dust counts than air taken at the street level at various office buildings in the business district of Boston. Tests made at the John Hancock Building on June 6, 1913, showed that at the street level the air contained 483,000 dust particles per cubic foot; at the fifth story there were 233,000, and at the tenth story, 140,000 per cubic foot. Tests made on July 2, 1913, in New York at the Metropolitan Life Insurance Building and the Woolworth Building, the last named being the highest building in the world, showed similar reductions in the amount of dust in the air in the upper stories.

For example, at the Woolworth Building the air at the street level contained 221,000 dust particles per cubic foot; at the tenth story there were 85,000, at the thirtieth story 70,000, and at the fifty-seventh story 27,300. The dust counts at the Metropolitan Building were somewhat lower than at the Woolworth Building, the number at the street level being 173,000, and at the fiftieth story 21,000 per cubic foot. The lower counts at the Metropolitan Life Building may possibly have been due to the fact that this building is situated near Madison Square and is more isolated than the Woolworth Building, which is located downtown in a more crowded section. Both sets of observations were made on warm, quiet days.

DUST PARTICLES IN INDOOR AIR USUALLY HIGH.

Winslow has shown that the air of many of the New York schools contains even larger numbers of dust particles than those above mentioned, ranging

from 400,000 to 1,000,000 per cubic foot. Studies by the authors at the gymnasium of the International Y. M. C. A. College at Springfield, Mass., have likewise shown that the indoor air contains dust particles in numbers usually more than 100,000, and sometimes even 400,000 per cubic foot. Such results are naturally to be expected, for indoor air is merely the outer air drawn in through the ventilating ducts, the inlets to which are often badly located, while to this outer air is added the dust resulting from friction and air movement of various kinds indoors.

PROPORTION OF LIVING BACTERIA IN DUST.

Unclean air contains bacteria and other living organisms as well as lifeless dust particles. The bacteria are usually much less numerous than the dust particles. Our investigations at the John Hancock Building show that at the street level the air contained 1,330 bacteria per cubic foot, capable of developing on gelatin at 20° F. in 96 hours, while at the tenth story the air contained 330 per cubic foot. Speaking broadly, it was found that there were from 200 to 300 times as many particles of dust as bacteria. The bacteria capable of growing at the temperature of the human body were still less numerous, there being only 30 such bacteria per cubic foot found at the street level and 17 at the tenth story The sample from the third story, however, contained 83 per cubic foot, evidently an erratic observation. No attempt was made to determine the particular species of bacteria in these samples, but tests were made for the presence of B. coli and only once was this organism found, namely, in the sample collected at the third story. Moulds were also present to the extent of 20 per cubic foot at the street level and 3 at the tenth story.

Winslow's studies of bacteria in the air of rooms and especially in the air of sewers and drains showed a conspicuous absence of pathogenic bacteria. Even in the case of sewer air and drain air the numbers of B. coli found were surprisingly small. Our own results corroborate Winslow's findings. Yet, in air, just as in water, B. coli may be regarded as an index of undesirable contamination. In this connection it will be remembered that Dr. Chapin, the well-known health officer of Providence, R. I., holds that the danger of transmission of disease by the air conveyance of bacteria is extremely small.

CHARACTER OF IMPURITIES CAUGHT BY AIR WASHERS.

Dust and bacteria do not constitute the only undesirable substances found in unclean air. Chemical examinations of the water from air washers in Boston disclosed the presence of ammonia compounds, nitrites, chlorides, sulphates, free sulphuric acid, and iron. The amounts of these substances varied with the locations of the intake ducts. Washers receiving air from the street level showed greater quantities of impurities in the water used for washing than those taking air from a height.

Mention has been made of the dust particles and bacteria in indoor air and of their tendency to outnumber those in outdoor air. The other constituents of indoor air are likewise subject to change Chief among these are the substances that give rise to odors. Everyone is familiar with the odor of a poorly ventilated room after occupancy by a number of persons. This is due in part to the presence of expired air and to body emanations that accompany physiological processes. The same condition prevails wherever people congregate in restricted quarters, such as halls, churches, theatres and cars. To some extent the intensity of these disagreeable odors is dependent upon the degree of activity of the occupants; witness the characteristically strong odor of a gymnasium. During the course of the Springfield experiments an increase of the odor of the air after the men began exercising in the gymnasium was very noticeable to one standing in the exhaust air duct.

FRESH AIR DEFINED AS CLEAN AIR IN MOTION.

There is no expression more common than that of "fresh air." Just what is meant by this term? It certainly does not involve the factor of air temperature to any extent, for we use the expression both in winter and in summer, and at times when the outside and indoor temperatures are the same. Neither does it involve humidity. In the opinion of the

writers it may be regarded as practically synonymous with clean air in motion, air that is free from dust, from bacteria, and from malodorous or offensive organic emanations and poisonous substances.

Too little attention has been paid in the past to the cleanliness of the air supplied to our buildings. Fresh air inlets are often located with the grossest disregard for the quality of the incoming air. It is not uncommon to see them placed on the sidewalk level, or facing a vacant piece of ground that is swept by clouds of dust, or where smoke or objectionable odors may be taken in. In one of the buildings of Harvard University the air inlet is placed near a main entrance, where automobiles stop and start, and the odor of spent gasoline frequently permeates the building.

The effect of forcing unclean air into buildings is to nullify the result aimed at by ventilation, that is, to provide a supply of fresh air. The presence of dust, bacteria and odors not only renders the conditions uncomfortable and deleterious to health, but it results in attempts at window ventilation, and this means poor ventilation, unequal heat distribution and drafts.

IMPORTANCE OF LOCATION OF INLET DUCT.

Supplying buildings with unclean air may often be obviated by a judicious choice of location for the inlet duct. A change of location from near the street to some higher point, or from one side of a building to another may greatly improve the quality of the influent air.

Crowded buildings and dusty city streets will often render it impossible to secure clean air from the outdoor atmosphere, without resorting to artificial purification. Fortunately this purification can be accomplished. Just as unclean water may be made wholesome by the employment of Nature's process of filtration, so can unclean air be purified by the application of another efficient process of Nature, namely air-washing. The purifying effect upon atmospheric air of a heavy fall of rain is well known A shower is said to freshen the air. Not only are suspended particles removed, such as dust and bacteria, but gaseous impurities, such as acids and ammoniacal vapors, are dissolved and removed, leaving the air sweet and clean. A determination of dust particles in the air after a heavy rain at Harvard University showed only 25,000 particles per cubic foot, whereas in dusty weather the numbers would have been measured by hundreds of thousand. This figure compares favorably with a determination made over the water of Long Island Sound at a point several miles from the shore, when the air contained 18,000 dust particles per cubic foot.

AIR WASHING TESTS AT BOSTON AND SPRINGFIELD.

To ascertain the efficiency of air-washing as a means of purification the authors made a study of this method as carried on at several buildings in Boston and Springfield, Mass.

Although it has been known that air washers tended to clean the air, and they have sometimes been introduced for that very purpose, their efficiency as a means of air purification has not been determined. Accordingly, the authors undertook a few preliminary studies in order to get data to serve as a guide in planning a more complete investigation. These studies were made at certain installations in Boston and Springfield, where washers made by different companies are in use, and included chemical and bacteriological analysis of the air before and after washing, and analyses of the water before its use and after different periods of use. At Springfield the studies formed a part of a more extensive series of ventilation studies made at the gymnasium of the International Y. M. C. A. College during the winter and spring months.

The washers in Boston referred to by the letters A, B, C, D and E were supplied with air taken from inlets placed as follows. They were all in the business district.

Washer	Position of Inlet
A.	Eighth story on the roof.
B.	Above street entrance.
C.	Second story, back side of the building.
D.	Street level, just above sidewalk.
E.	Street level, just above sidewalk.

The analyses of air and water were made by the standard method of the American Public Health Association,

supplemented by the use of special apparatus. The results are given in Tables 1 and 2.

ANALYSIS OF AIR WASHER TESTS.

Comparison of the dust counts in the air before and after passing through the water showed that in the case of the five Boston washers the percentage of removal ranged from 27% to 87% and averaged 54%, while the removal of bacteria ranged from 37% to 88% and averaged 64%. Generalizing from the data given in Table 1 it is fair to say that the air-washing process as practised removed about two-thirds of the suspended particles, including dust, bacteria and moulds.

The nature of the substances removed by the washers is shown by Table 2. Quantitatively these figures mean little, apart from a knowledge of the volume of water used and the number of times that the same water had passed through

TABLE I. SHOWING REMOVAL OF BACTERIA AND DUST PARTICLES FROM AIR BY VARIOUS AIR WASHERS, BOSTON, MASS.,

Source of Sample of Air.	Date. 1913.	Bacteria per Cubic Foot — Gelatine at 20° C. No.	Gelatine at 20° C. Per Cent. Removal.	Litmus Agar at 38° C. No.	Litmus Agar at 38° C. Per Cent. Removal.	Moulds per Cu. Ft. (Gelatine).	Dust Particles per Cu. Ft. No.	Dust Particles per Cu. Ft. Per Cent. Removal.
Washer A—								
Outside	Feb. 3	10	..	0	..	10	229,600	..
Washed	Feb. 3	5	50%	0	..	0	30,500	87%
Outside	Feb. 10	110	..	0	..	8	111,100	..
Washed	Feb. 10	13	88%	0	..	3	58,000	48%
Outside	May 13	1,000	..	7	..	20	178,300	..
Washed	May 13	300	66%	7	0%	7	124,700	30%
Washer B—								
Outside	Feb. 1	27	..	17	..	10	158,300	..
Washed	Feb. 1	17	37%	7	55%	3	71,300	55%
Washer C—								
Outside	Mar. 13	13	..	3	..	0	248,000	..
Washed	Mar. 13	3	77%	0	100%	0	72,000	71%
Washer D—								
Outside	Mar. 13	57	..	3	..	13	241,000	..
Washed	Mar. 13	7	88%	3	0%	3	104,000	57%
Washer E—								
Outside	May 1	187	..	20	..	20	729,300	..
Washed	May 1	110	41%	7	65%	13	531,000	27%

TABLE II. SHOWING ANALYSIS OF TAP WATER BEFORE USE, AND OF WATER FROM VARIOUS AIR WASHERS IN BOSTON, MASS., AFTER USE.

	Before Use — Tap Water 1	Before Use — Tap Water 2	Washer A 1	Washer A 2	Washer A 3	After Use — Washer B	Washer C	Washer D	Washer E
Date of colection 1913	Feb. 1	Mar. 13	Feb. 3	Feb. 10	May 13	Feb. 1	Mar. 13	Mar. 13	May1
No.. of hours water had been circulated	..	..	192	360	48	75	24	34	9
Temperature F°	..	..	45°	34°	52°	50°	50°	63°	59°
Turbidity	0	1	3	16	6	35	35	145	28
Color	10	16	15	20	15	17	10	20	39
Odor	2v	1v	3v	3a	3a	3a	2v	3a	3d
Total residue	34.0	40.0	55.0	107.0	96.0	560.0	238.0	765.0	160.0
Loss on ignition	16.0	17.0	13.0	27.0	21.0	151.0	78.0	240.0	46.0
Fixed residue	18.0	23.0	42.0	80.0	75.0	409.0	160.0	525.0	114.0
Kjeldahl nitrogen	0.190	0.168	0.228	0.580	0.220	2,780	0.510	1.740	2.650
Albuminoid nitrogen	0.068	0.084	0.084	0.132	0.106	0.332	0.136	0.850	0.425
Free ammonia	0.002	0.018	0.148	0.144	0.042	1.512	0.280	2.350	2.330
Nitrites	0.000	0.001	0.011	0.011	0.006	0.056	0.010	0.024	0.060
Nitrates	0.10	0.18	0.09	0.05	0.05	2.50	0.15	0.14	0.18
Oxygen consumed	2.5	3.4	3.5	5.5	4.1	10.0	6.2	26.4	8.2
Chlorine	5.0	5.0	5.0	5.2	5.0	16.0	7.0	19.0	10.0
Total hardness	11.0	14.5	20.0	28.5	30.0	307.5	130.0	357.5	45.5
Alkalinity	6.0	7.0	0.0	0.5	0.5	—1.5	—4.5	0.0	—0.5
Incrustants	5.0	7.5	20.0	28.0	29.5	309.0	134.5	357.5	50.0
Iron	0.5	0.2	0.4	1.4	0.7	10.0	7.5	32.0	3.5
Copper	..	..	+*	+	0	+	+	+	0
Total bacteria, Nos. per c.c. Gelatine 4 days at 20° C.	25	50	25	15	1,200	60	0	0	8,700
Litmus Agar 2 days at 38° C.	7	..	2	1	3	10	0	0	12
Moulds per c. c. (gelatine).	5	..	3	5	..	10	..	..	30

* + Signifies that copper was present. 0 Signifies that copper was absent.

the air, and exact data for this could not be obtained. From a comparison of the analyses of the tap water before use with the washer water after use it is evident that many substances were removed from the air besides dust and bacteria.

When street air was passed through a washer it required but a few hours for the water used to resemble sewage in appearance and analysis. A comparison of the analyses of washers B, D and E with those of C and A given in Table 3 shows how much greater was the amount of dust removed from air near the street level than at higher elevations. The intake ducts of these washers were at the street level, the second story and the eighth story, respectively.

SULPHUROUS ACIDS CAUSE OF INTERESTING PHENOMENON.

The presence of sulphurous acids in the air of the business district of Boston was responsible for an interesting phenomenon. These acids resulted from the formation of sulphurous gases during the combustion of coal and, being soluble, were removed from the air and dissolved by the water in the air-washing process. As long as the water contained alkalinity the sulphuric acid was neutralized, but after a certain length of time an excess of acid was present. This condition was found in several washers. Where it occurred in a washer constructed largely of copper the acid dissolved this metal and formed copper sulphate. As a result there was established a sort of automatic process of disinfection, and the numbers of bacteria found in the washer water were very low.

TABLE III. AVERAGE ANALYSIS OF WASHER WATERS.

(Results Expressed in Parts per Million).

	Water Before Use.	Intake at Street Level.	Intake at Second Story.	Intake at Eighth Story.
Turbidity	1	69	35	8
Total residue	37.0	495.0	238.0	86.0
Loss on ignition	17.0	148.0	78.0	20.0
Kjedahl nitrogen	0.179	2.390	0.510	0.343
Free ammonia	0.010	2.064	0.280	0.111
Oxygen consumed	3.0	14.9	6.2	4.4
Iron	0.35	15.2	7.5	8.0

AIR FROM GYMNASIUM WASHED AND RECIRCULATED AT SPRINGFIELD.

The gymnasium of the International Y. M. C. A. College at Springfield afforded an opportunity of studying a new phase of the problem of air washing, namely that of purifying air that had passed through an occupied room. It was supplied with air from a ventilating plant provided with an air washer operated at such a rate that the air in the room was changed every nine to twelve minutes. This plant was well adapted for experiment for the reason that air could be taken in from the outside and washed, or the exhaust air from the room could be returned through the washer and again forced into the gymnasium. Comparison could thus be made between the use of outside air and of rewashed air. As in the Boston experiments analyses were made of the air before and after washing and of the water after different periods of service. Frequent tests were made under different conditions of operation.

When the exhaust air left the gymnasium it had a noticeably sour and musty odor. After passing through the washer this was almost completely removed and the returned air was fresh and sweet. At the same time the "gymnasium odor" was acquired by the washer water and could be easily detected in the sample bottles. The washer water was also found to contain large numbers of bacteria and many epithelial scales derived from the skin of the men exercising on the floor. Dust, bacteria, moulds, nitrogen and iron were removed from the indoor air by the washer at Springfield to about the same extent as by the washers tested in Boston.

The results indicated that under the conditions there existing the exhaust air could be washed and returned to the gymnasium with entire safety and comfort to the occupants of the room and with no apparent sacrifice of wholesome properties. The carbonic acid was not reduced by the air washer—and theoretically it ought not to be reduced—but

this fact did not at all affect the acceptability of the washed air to the occupants. The details of these experiments are described in *The American Physical Education Review* for September, 1913. Generalizing from these results, it may be said that the recirculated air after washing was cleaner than unwashed outdoor air, but was slightly less clean than the outdoor air after washing.

ECONOMY OF WASHING AND RECIRCULATING AIR.

The advantage of washing and recirculating the air lies in the great saving of heat in cold weather. Mr. D. D. Kimball, who designed the ventilating plant at Springfield, estimated that when the outdoor temperature was 32° F. the saving in cost of operation effected by recirculating washed air was 40%, while, with an outdoor temperature of 0° F. the saving was 50%. The use of less coal at Springfield when the air was being recirculated instead of being drawn in from outdoors was plainly evident, and was commented upon by the engineer in charge of the Springfield plant. In the summer the washer may be operated as a cooling plant to keep down the temperature of the indoor air, or with the windows open it may be shut down to save expense.

The common standard of 30 cu. ft. of air per capita per minute, which is now generally applied to schoolhouses, was based upon the idea of keeping the carbonic acid down to a fixed amount. When it became recognized a few years ago that carbonic acid was a negligible factor, some made the inference that a smaller volume of air would suffice. They failed to consider that circulation of the air is of itself one of the essential elements of indoor comfort and a necessary feature of good ventilation.

The cost of heating large volumes of cold air has naturally stood in the way of efficient ventilation of schools and factories during the cold weather. Another difficulty has been the low indoor relative humidity produced by heating outdoor winter air to a comfortable room temperature. If, therefore, both of these objections can be overcome by washing air and using it over and over so as to furnish an ample supply of clean air in motion the method is one that has much to commend it. Naturally there would be a limit to the continued use of the same air, but ordinary leakage and the possible use of a small percentage of outside air would prevent the concentration of any substances not removed by the washer.

Our study of the subject of air washing has led us to believe that it is one of the vital elements of ventilation in localities where it is difficult to obtain a supply of clean air, and that the recirculation of air thus washed is deserving of serious consideration from the standpoint of economy. It is very evident that the air washers now in operation are not giving as high a degree of efficiency as might be obtained with better designs and more skillful operation, and the details of the process should be submitted to careful scientific research.

The Ventilation of Cellars.

A cool place should never be ventilated unless the air admitted is cooler than the air within, or is at least as cool as that, or a very little warmer. The warmer the air, the more moisture it holds in suspension. Necessarily, the cooler the air the more this moisture is condensed and precipitated.

When a cool cellar is aired on a warm day, the entering air, being in motion, appears cool; but, as it fills the cellar, the cooler air with which it becomes mixed chills it, the moisture is condensed, and dew is deposited on the cold walls, and may often be seen running down them in streams. Then the cellar is damp and soon becomes moldy.

To avoid this, the windows should only be opened at night, and late—the last thing before retiring. There is no need to fear that the night air is unhealthful; it is as pure as the air of midday, and is really drier. The cool air enters the apartment during the night and circulates through it.

The windows should be closed before sunrise in the morning, and kept closed and shaded through the day. If the air of the cellar is damp, it may be thoroughly dried by placing in it a peck of fresh lime in an open box. A peck of lime will absorb about 7 lbs., or more than three quarts of water, and in this way a cellar or milk room may soon be dried, even in the hottest weather.

School Ventilation in New York City

ACTUAL TESTS IN 32 SCHOOL BUILDINGS WITH VARYING EQUIPMENT.

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(Read at the convention of the American Public Health Association, Colorado Springs, Colo., September 9, 1913.)

As a part of a comprehensive investigation of the educational system of New York City, conducted by a committee of the Board of Estimate and Apportionment, Prof. Charles Baskerville and the writer were asked to make a study of the existing atmospheric conditions in the schools. Our task was to, first, find out whether the air to which the children were exposed during their school hours was satisfactory in quality, and, second, how far any differences observable between different schools were correlated with differences in ventilation plan or operation.

The examination of all the 600 schools in New York was obviously out of the question, but we selected 32 typical examples, ranging from modern and well-managed fan-ventilated schools to older buildings in congested tenement districts, ventilated without fans, and including buildings of various sizes from one of the largest high schools to a four-room country school in Richmond Borough.

Ten of these schools were studied intensively, being visited once a week between December 2, 1912, and February 14, 1913, while the other twenty-two were visited on one or more occasions between February 14 and March 15, 1913.

Temperature and humidity observations were made with the standard U. S. Weather Bureau sling psychrometer and were supplemented by the use of Tycos thermographs, giving us continuous records for 364 different school days. Carbon dioxide determinations were made with the portable Patterson-Palmquist apparatus modified and improved for our purposes in certain minor details. Microbes in the air were enumerated by filtering a measured volume of air through a sand filter, washing the sand in sterile water and plating on litmus-lactose-agar, the general method recommended by the Committee of the Laboratory Section of the American Public Health Association on Standard Methods for the Examination of Air.

Dust particles were determined by passing the air through a sugar filter, dissolving the sugar in a measured amount of water and counting the particles in an aliquot portion under the 2/3-in. objective, another of the procedures recommended by the Committee on Standard Methods.

Altogether we made 1,832 observations of temperature and 1,825 of relative humidity, with 790 determinations of carbon dioxide, 684 of microbes and 650 of dust particles.

In addition to these routine observations we made a special study of air supply and air circulation in certain selected schools by the use of the anemometer and joss sticks and by an elaborate series of local temperature observations at different points within the rooms; and we had conducted (by Dr. D. R. Lucas) a special investigation of the specific proteid material which Prof. Rosenau believes it is possible to detect in air by the use of the anaphylactic reaction.

GENERAL ATMOSPHERIC CONDITIONS IN NEW YORK SCHOOLS.

The general results of our routine studies are indicated in Fig. 1. They are expressed in the form of distribution curves, the abscissae representing the observed values in each case and the ordinates the percentage of all observations falling within the limits of values indicated below.

Taking the upper graph first it should be noted that, although the curve is labelled "Bacteria," it really includes

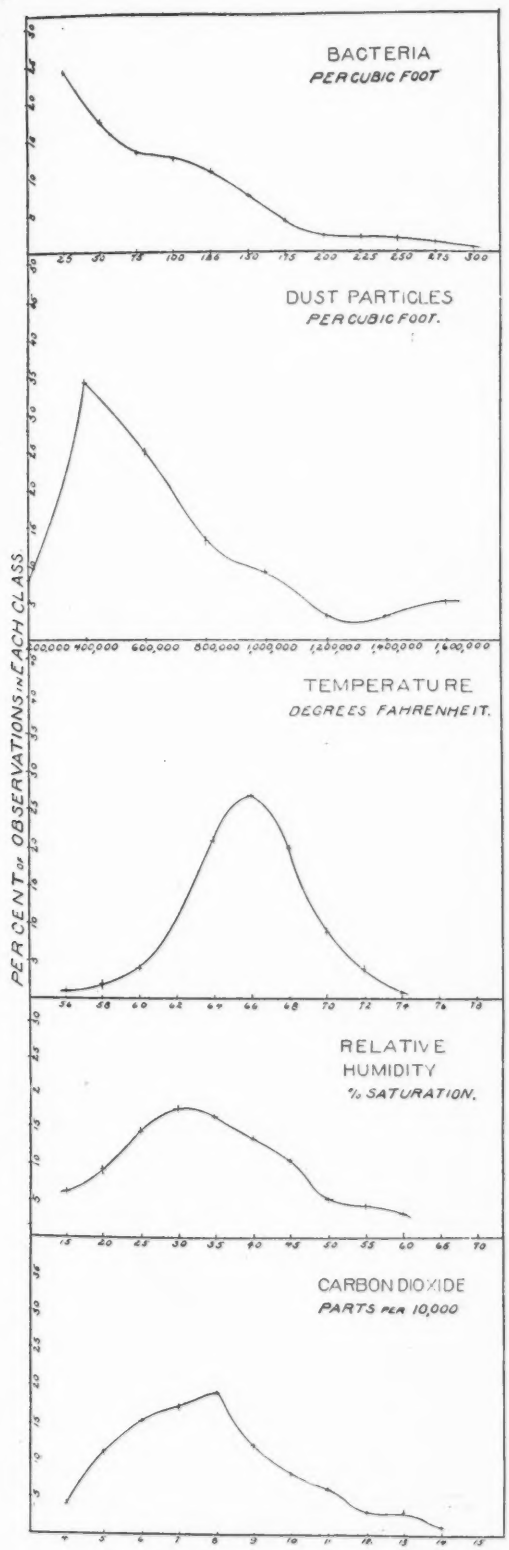


FIG. 1.—GENERAL DISTRIBUTION OF OBSERVATIONS AS TO THE QUALITY OF NEW YORK SCHOOLROOM AIR.

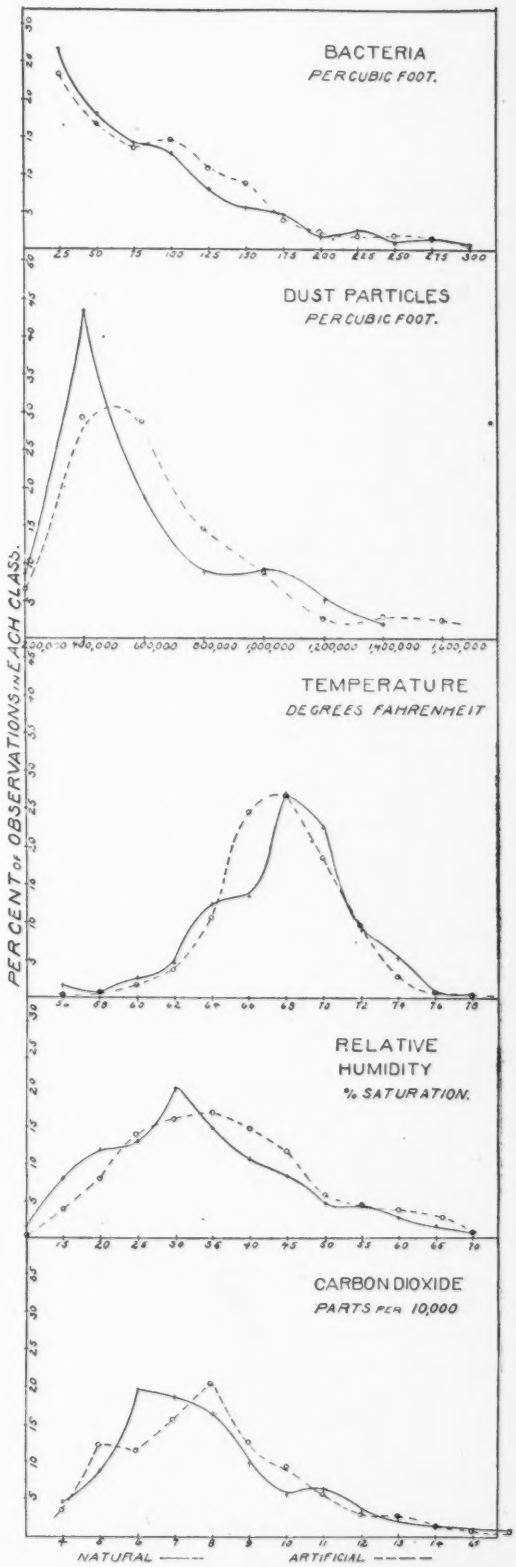


FIG. 2.—COMPARISON OF AIR CONDITIONS IN NATURAL AND ARTIFICIALLY-VENTILATED SCHOOLS.

yeast and molds as well; all microbes, in fact, which will form visible colonies on litmus-lactose-agar in five days at room temperature. The most frequent result is 25 microbes or less per cubic foot, but the high results pull the general average up to 96. However, 68 per cent. of the samples showed counts of 100 or less and only 9 per cent. over 200.

These counts include aii sorts of organisms, from all sorts of sources, which are able to withstand drying long enough to be lifted up and blown about in the air. Most of them, of course, are of no sanitary significance; and the values, averaging under 100 per cubic foot and in most samples much less, must be considered satisfactory by comparison with the results reported by Miquel (150 bacteria per cubic foot in the air of Paris), by Tenon (40-60 bacteria per cubic foot in quiet hospital air), by Hesse (60 bacteria per cubic foot in a class-room before the students arrived, raised to 430 during the hour and 1,000 just after the class had left), and by Soper (140 bacteria per cubic foot at remote end of Fulton Street Subway station.

FEW BACTERIA OF HUMAN ORIGIN.

In order to obtain an estimate of the bacteria of human origin, which might at times include pathogenic forms, we made all our plates on litmus-lactose-agar, as noted above, and isolated all red colonies which appeared on the plates.

It is well established that acid forming streptococci are among the most abundant forms in the human mouth, while they are absent from sources which have not recently been exposed to human or animal pollution. The numbers of these organisms in school-room air were found by Prof. Baskerville and myself in preliminary experiments a year ago to be quite small. We then found among 30,000 colonies isolated from 750 plates, exposed in schools with window ventilation, only ten mouth streptococci.

In the present study, in the examination of a total of 868 cu. ft. of air, we found 52 mouth streptococci, or six for every 100 cu. ft. of air. The average number of mouth streptococci for the individual schools ranged for the most part between two and seven per 100 cu. ft. In one crowded school in a poor district it rose to 15 per 100 cu. ft., and in a school in a good semi-suburban district, no streptococci were found in 41 cu. ft. of air. The general average of six mouth streptococci per 100 cu. ft. gives a ratio of about one of these forms to 1,600 total bacteria.

A child breathes less than 100 cu. ft. of air during an average school period and these mouth streptococci must, of course, be far more abundant than pathogenic forms. At a rate of four or five mouth streptococci per day the chance of ingesting pathogenic bacteria from the air is seen to be a very slender one.

ORDINARY SCHOOL-ROOM DUST NOT HARMFUL.

The general distribution of dust counts is shown in the second graph of Fig. 1. The largest number of samples showed between 200,000 and 400,000 particles per cubic foot. The general average for all schools was 601,000 particles and 20 per cent. of the samples showed 800,000 or more, with a few values ranging up to 2,000,000 and over.

The sanitary significance of these results is probably not great. Dust particles constitute a serious menace to health in industrial establishments, grinding shops, granite cutting sheds and the like, since the hard metallic or mineral particles which are found under such conditions injure the lung tissue and often form a controlling cause in the development of industrial tuberculosis. There is no evidence, however, to show that such particles as occur in ordinary school-room air have any such significance. The particles which we found were for the most part minute and chiefly organic in nature. In the counting cell they separated into two layers, the greater number, floating on the surface, being barely visible under the microscope and consisting in large part of mold spores; while less numerous particles settling on the bottom included larger shreds of vegetable fiber and inorganic matter. There is no reason to suppose that particles of such small size and of such nature as were found exert any influence on health.

TEMPERATURE RECORDS SHOWED GOOD CONDITIONS.

The general results of the 1,832 temperature observations made by our field

squads with the sliding psychrometer are plotted in the central curve of Fig. 1.

It is evident that these records as a whole indicate very good conditions. The temperature curve centers closely, as it should, about 68°. Only 14 per cent. of all records showed over 71° and only 5 per cent. over 73°. Sixty-eight per cent. of all records fall between 66° and 71°, a reasonable and equable temperature. On the whole this result must be considered highly creditable and an indication that the children of the New York schools for the most part enjoy good atmospheric conditions, free from objectionable overheating. An examination of particular schools, however, shows that this general curve covers up markedly different conditions in individual cases.

The general distribution of results in regard to relative humidity are shown in the fourth curve of Fig. 1.

WIDE HUMIDITY RANGE.

The range of relative humidity is seen to be a wide one. Sixty per cent. of all observations, however, fall between 20 per cent. and 40 per cent. of saturation and the general average for all schools is 35 per cent., indicating a distinctly dry atmosphere.

We found a close correlation between outdoor temperature and indoor relative humidity, closer if anything in the naturally-ventilated than in the artificially-ventilated schools. This is an important point, in view of the criticism often leveled at the supposedly abnormal air of fan-ventilated schools. It does not make the least difference whether air is heated in the ducts or in the rooms, the same rise in temperature producing the same drying effect.

The only way to avoid dry air in the school-room with certainty is by means of fan ventilation, combined with artificial humidification. We studied two examples of this in School 6, Brooklyn (where the air is washed in an air-washer of the spray type) and in School 27 (where half the building has air humidified by a steam jet). Neither school has automatic humidity control. The air in these schools was moister than the average, though not very markedly so. In School 6 75% of all observations were under 50% saturation and 21% under 35% saturation, the corresponding proportion of observations falling in these classes being 83% and 58% for the humidified half of School 27 and 90% and 62% for the average of all schools.

How far we are justified as sanitarians in demanding effective artificial humidification of school-room air seems to me very uncertain. There is a strong and probably correct impression that very dry air in the school-room is objectionable, but this impression rests on no sound basis of demonstrated fact, and there are, so far as I am aware, no physiological experiments which enable us definitely to say that a humidity of 50% or 25% of saturation is harmful to health.

CARBON DIOXIDE TESTS.

Our results in regard to carbon dioxide are summarized in the lowest graph of Fig. 1.

The general average value for all schools was 8.1 parts per 10,000. Sixty-six per cent. of the observations fell below 8.5 parts, which may be considered a very satisfactory result on any standard. Twenty-nine per cent. of the tests showed between 8.5 and 12.5 parts, which would have been considered high on the older standards established when carbon dioxide was held to be a measure of some mysterious poisonous matter in the air.

There remain 6% of the tests, however, showing over 12.5 parts, which are clearly excessive. These were associated with overcrowding and deficient air supply in individual rooms.

Supplementing observations made in four schools during evening sessions (when there is no artificial ventilation) showed some very high carbon dioxide values ranging, in one case with gas burning, up to 26.0 parts. This is a special problem which deserves more attention than it receives in many cities.

STUDIES OF AIR SUPPLY AND AIR CIRCULATION.

Our analytical data were supplemented by a study of the distribution of air to individual rooms and its circulation within the rooms themselves which are of some interest as showing how the mechanics of ventilation work out in practice.

Inlet and outlet velocities were studied with the anemometer in 50 rooms, 25 in one of the best fan-ventilated schools (33 Bronx), 16 in four fan-ventilated schools where high carbon dioxide values had been found and 9 in four schools ventilated without fans. The amount of air supply in the fan-ventilated schools showed that in School 33 the amount was more than ample, while in the poorer school it was inadequate.

In School 33 the effective area of the inlets averaged 5.1 sq. ft. and of the outlets 5.6 sq. ft., and the linear velocity at inlets and outlets respectively averaged 373 ft. and 141 ft. In the sixteen poorly ventilated rooms the average inlet area was 4.4 sq. ft., the average outlet area 4.0 sq. ft., the average inlet velocity 189 lin. ft., and the average outlet velocity 83 lin. ft. The average number of pupils per room was 35 for School 33 and 45 for the sixteen poorly ventilated rooms. For the most part we found a good plenum condition in all the fan-ventilated rooms. The very high ratios were usually in rooms with doors or windows open.

The results obtained in the naturally-ventilated rooms are not very significant, since doors and windows were freely opened. It is of interest to note, however, that in one school we found inlet velocities of 200 and 300 lin. ft. per minute without fans, maintained by enormously high temperatures of inlet air.

The circulation of air within the rooms themselves was studied by the use of smoking joss sticks and by an elaborate series of local temperature measurements. The results obtained by the use of the joss sticks in about 70 rooms were very hard to generalize. In about half of the fan-ventilated rooms there were clean cut currents which could be traced across the upper part of the room, down the side wall opposite and back along the floor to the outlet. In an equal number of cases, however, the currents were indefinite and broken and in a few cases no currents at all could be discerned. In the rooms without fans the currents were usually very erratic, although in one or two cases a definite circulation was produced by windows open at top and bottom. In general the naturally-ventilated rooms were much more subject to local drafts than were those ventilated by fans.

LOCAL TEMPERATURE OBSERVATIONS.

The local temperature observations were on the whole more valuable as throwing light on air circulation. In 24 rooms in fan-ventilated schools we found an average increase in temperature between inlet and outlet of 4.3° F.

The outlet temperature corresponds very closely to the general room average. This indicates that the outgoing air is a pretty fair sample of that in the room and that its temperature may be taken as a fair measure of that of the room as a whole.

The difference between bottom (3 ft. above floor) temperature and top (12 ft. above floor) temperatures was inconsiderable, and more variable than might have been expected. Of twenty-six rooms in which both were determined, just half showed a higher temperature at the top than at the bottom, while in the rest the upper air was cooler. The top excesses were higher than the bottom excesses, however, averaging over 2.0° instead of under 1.0°.

The slight extent of the differences observed is probably due to the fact that, on the one hand, cool air was being blown in at the top of the room while, on the other hand, the air, as it was warmed in the room, tended naturally to rise. This condition must interfere to some extent with normal air circulation and offers a certain argument in favor of upward as opposed to the usual downward ventilation.

Finally, the range between the maximum and minimum individual temperatures observed in the room is significant as a measure of general air circulation. The differences ranged for individual rooms between 1.7° and 12.0°, and averaged 5.8°, showing on the whole a fairly good mixture of the air. These observations were all made in fan-ventilated rooms.

In rooms ventilated without fans, conditions were more variable. Among eighteen rooms without fan-ventilation (that is, without a current of cool air blown in near the top) all but one showed a higher ceiling temperature, the excess in two cases being over 11.0°, and averaging 5.8°.

Another marked difference between the fan-ventilated and the artificially-ventilated rooms lies in the evenness of tem-

peratures at different points. The range of difference between maximum and minimum room temperatures for the fan-ventilated rooms, as noted above, was from 1.7° to 12.0°, and the average 5.8°. For thirty-eight naturally-ventilated rooms, it ranged from 1.2° to 20.2°, and averaged 7.9°. Obviously, the air circulation is rather defective when such conditions exist.

It may be of interest to note that in five of the naturally-ventilated rooms, all in one building, the temperature of the incoming air was respectively 83°, 86°, 90°, 98° and 125° F. In the latter case one of our thermometers (registering to 130°) was burst by the heat of the inlet air the first time the temperature was taken.

COMPARISON BETWEEN NATURALLY AND ARTIFICIALLY VENTILATED SCHOOLS.

For the purpose of estimating the value of fan ventilation, as actually operated in New York, curves were plotted for all the schools classified on this basis and this curve is reproduced in Fig. 2. Of course, it must be understood that by natural ventilation is meant simply that fans were not running. In almost all cases ducts and often heating coils were there and air was undoubtedly passing through them. So, on the other hand, where fans were in operation, windows were often open and outside air passing in or out through them. The distinction is made solely on the fact that fans were or were not in operation in connection with the particular room in which each test was made.

The general results for the two classes of schools are on the whole remarkably alike. The fan-ventilated schools show more dust, more humidity, more carbon dioxide and a somewhat more equable temperature; but none of the differences are very great or very significant.

In dust and carbon dioxide, the fan-ventilated schools appear slightly inferior to the others. In humidity they are better (if dry air be a disadvantage.) In temperature they are also somewhat better, showing less observations over 72°.

So far as temperature is concerned, however, it should be noted that the curve for the fan-ventilated class conceals wide variations between the individual schools included in it. Of our ten regular schools it is noteworthy that the four really good records (from the standpoint of temperature) were in fan-ventilated schools. The three wholly or partly naturally-ventilated schools are mediocre or poor; and two fan-ventilated schools are worst of all.

In Fig. 3 are shown typical curves for these three classes. Either almost perfect conditions or very poor conditions may be obtained with fan-ventilation according to the care and intelligence of the janitor in charge.

On the whole it can be said that, comparing the actual condition of rooms ventilated with and without fans, New York was not last winter deriving any material advantage from its fan-ventilation as actually operated.

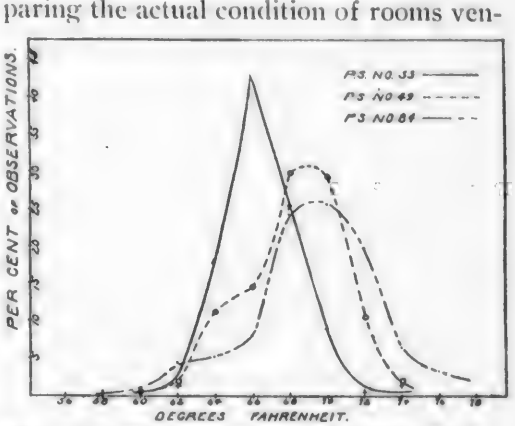


FIG. 3.—TEMPERATURE CURVES FOR A GOOD FAN-VENTILATED SCHOOL (33), A NATURALLY-VENTILATED SCHOOL (49), AND A BADLY-OPERATED FAN-VENTILATED SCHOOL (84).

THE PROBLEM OF OPERATION.

This brings us to the crux of the whole matter, as it was made evident in this investigation, the problem of careful operation.

We found certain schools of either the fan-ventilated or the naturally ventilated type which had an ample air supply and uniformly low carbon dioxide values. We found other schools, of both types, in which the supply of air was inadequate and carbon dioxide figures consequently high. In the case of fan-ventilated schools this usually meant low inlet velocities (some times inadequate inlet areas) or overcrowding, while in the naturally-ventilated schools it meant either overcrowding or neglect to open windows.

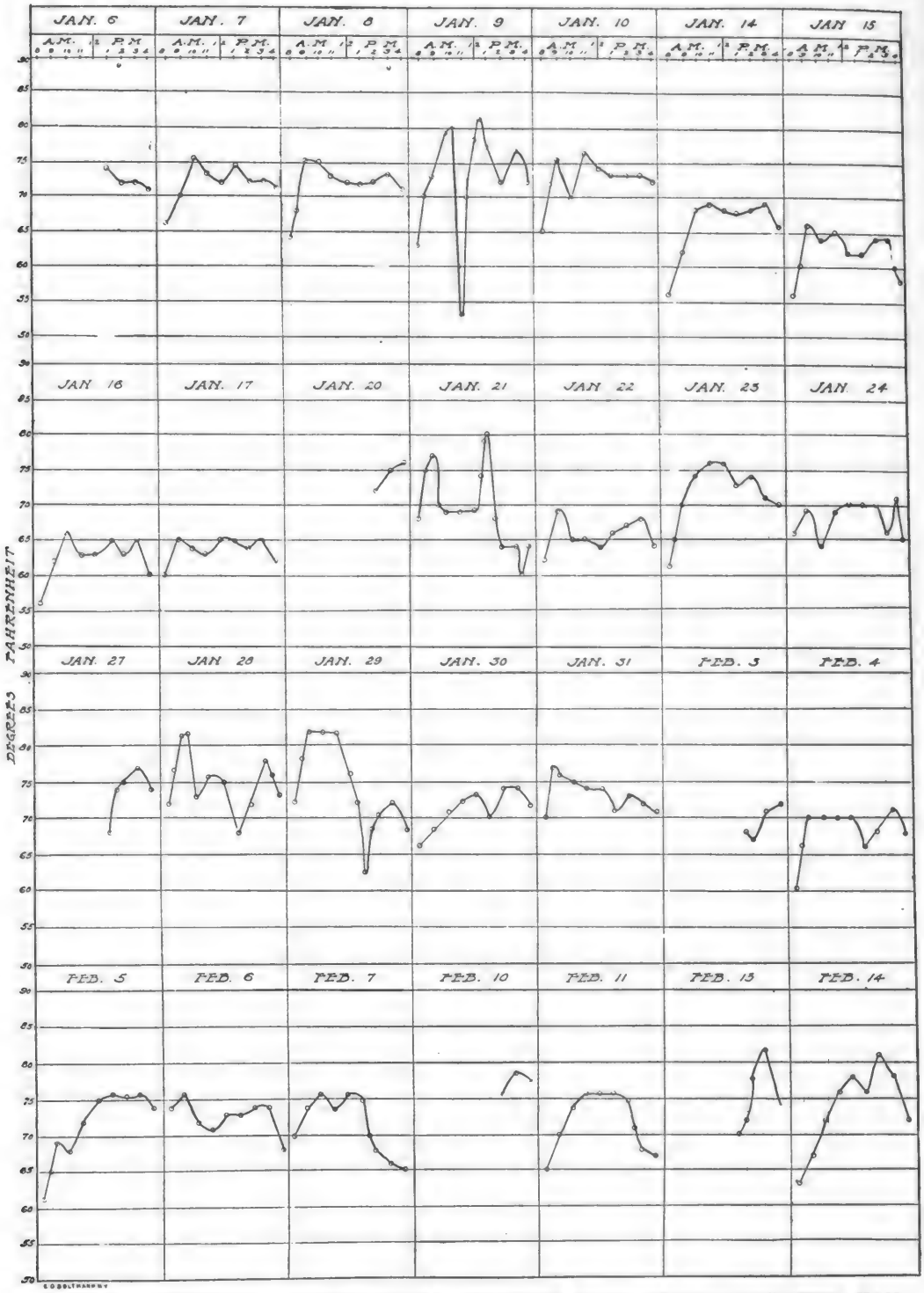


FIG. 4.—AUTOMATIC TEMPERATURE RECORDS IN A BADLY-OPERATED FAN-VENTILATED SCHOOL.

It may be noted that the worst carbon dioxide record obtained in any school was in a four-room country school in Richmond Borough heated by hot air (five records out of eleven, over ten parts, and three over twelve parts), and the next in a large plenum school on the East Side (23 out of 54 records, over ten parts, and ten over 12 parts). In the latter case the special rooms studied showed an air supply of only 14.2 cu. ft. per pupil per minute.

The most striking results of careless operation were shown, however, in the matter of overheating. In the case of the naturally-ventilated schools the co-operation of both janitors and teachers is required in order to secure good results, and, where so many persons are concerned, it is practically impossible to reach a maximum of efficiency. Such a result as that indicated in Fig. 3 for School 33 could scarcely be attained where window ventilation plays any large part.

In fan-ventilated schools, on the other hand, the whole responsibility rests (or should rest) with the janitor, and either very good or very bad results may be attained, according to his intelligence and responsibility. The continuous records obtained by our recording thermographs brought out the importance of the operating factor with startling clearness and four of our curves are reproduced herewith to illustrate the variation which occurred.

In order to remedy this condition we urged that a thermograph of some improved type be installed in each school building and that the records obtained be carefully inspected and made the basis for an efficient control of ventilating systems and janitorial service and we recommended that these records be supplemented by periodical studies of temperature and volume of air at the room inlets.

CRITERIA FOR SCHOOL-ROOM AIR.

The chief value of these investigations lies perhaps in their possible use as a basis for comparative studies in the schools of other cities, which are greatly needed if scientific records are to take the place of opinion in the field of school ventilation.

The results obtained in regard to dust and bacteria seem to indicate that, so far as these suspended matters are concerned, the air of the New York schools is in a satisfactory condition, without any special measures of protection such as ozone disinfection or air washing.

So far as carbon dioxide is concerned, our results indicate that it is comparatively easy, either with or without the use of fans, to keep the air in a school room so changed that its carbon dioxide will average well under 10 parts per 10,000 and will rarely exceed 12 parts. This test furnishes an excellent measure of air change and under ordinary conditions such an air change is essential in order to remove odors and preserve a freshness agreeable to the senses. Where air is recirculated, however, with washing or chemical treatment to remove odors, the carbon dioxide standard may have to be relaxed still further, although it will always be of value as an index of what is going on in the way of air dilution.

In view of the claim of Rosenau and Amoss that specific proteid compounds of human origin can be detected in respired air by the delicate physiological reaction of anaphylaxis, we devoted considerable attention to this point. Dr. D. R. Lucas, who conducted this part of the investigation, was able easily to demonstrate the presence of such specific proteid substances in the saliva under carefully controlled conditions, but was unable to detect them in material condensed from the breath or in air heavily contaminated by the respiration and exhalation of dogs and human beings. We were forced to conclude that "there is at present considerable uncertainty as to the presence of such specific proteid substances in demonstrable amounts in respired air and that there is absolutely no evidence of the presence of any organic substances of a deleterious nature in such air."

Similar experiments carried out simultaneously by Dr. Charles Weisman at Columbia University and published as a Doctors' Dissertation have led to the even more definite conclusion that "the results of these experiments disprove the statements of Rosenau and Amoss that the breath contains 'volatile' protein and that such 'volatile' protein is an important respiratory factor."

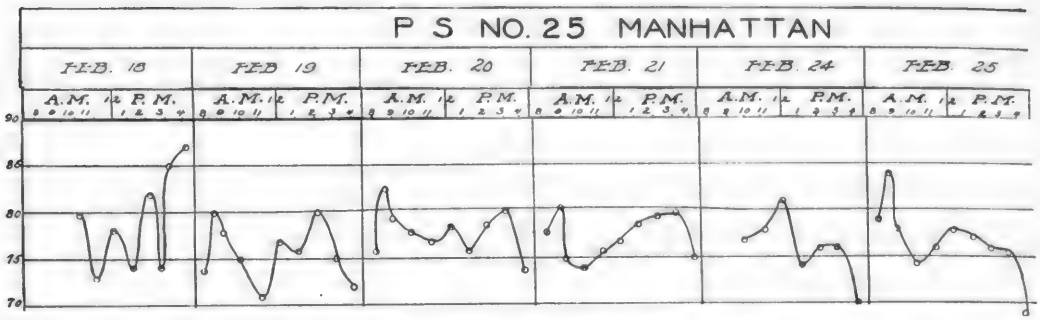


FIG. 5.—AUTOMATIC TEMPERATURE RECORDS IN A BADLY-OPERATED NATURALLY-VENTILATED SCHOOL.

There seems no good reason to doubt the general soundness of the conclusion arrived at by Flügge eight years ago that "Whenever in closed, crowded rooms certain impairment of health ensues, such as headache, dizziness, nausea, etc., these symptoms are to be attributed solely to heat retention."

This position may at any time be modified by experiments demonstrating the presence of chemical poisons in respired air, but such experiments have not yet been made public, and at present it seems clear that overheating is the chief evil to be guarded against in conditioning the air of schoolrooms.

Finally, the problem of humidity is a most important one, but its satisfactory answer must wait for further physiological investigation. The air of all school rooms kept at a temperature between 60° and 70° in winter must necessarily be dry, as we have found it in New York, unless artificial humidification be resorted to. How far such artificial humidification is required, however, cannot, as it seems to me, be definitely stated without a sound physiological basis which is still lacking.

Theory and Practice in Engineering

IV.—Warm Air Heating and Ventilating.

By Konrad Meier.

(This series of articles commenced in the June, 1913, issue.)

The writer is not in favor of warm air heating on the whole, mainly because of the resulting condition of the air and other hygienic reasons, but sometimes it seems advisable to use air as a heat carrier. Whether it be done by furnace or by indirect steam or hot water, it may pay to investigate if the mechanical efficiency of the average plant could not be improved upon.

The final results with such apparatus, as with all others, depend greatly upon proper delivery. In gravity systems, the power to move the fluid is supplied by a very small fraction of the heat to be conveyed. Hence it must be applied judiciously and husbanded. This is true, particularly, with first-class apparatus, where it is desirable to use ample volumes at moderate temperatures, that is, where the work of handling the air is greater and the power very slight, as compared with the old way of heating with small flues at high temperatures.

Figs. 5 and 6, taken from "Mechanics of Heating and Ventilating," may illustrate the factors to be taken into account. For a closed circuit, the conditions are similar to those obtaining in a hot water system. The temperature difference of 135°—70° F. and the elevation of the mean level of cooling, where the air is giving up its heat (20 ft.), determine the total pressure (0.165 lbs. per square foot) obtainable directly by chart. The flues are sized so as to make up that

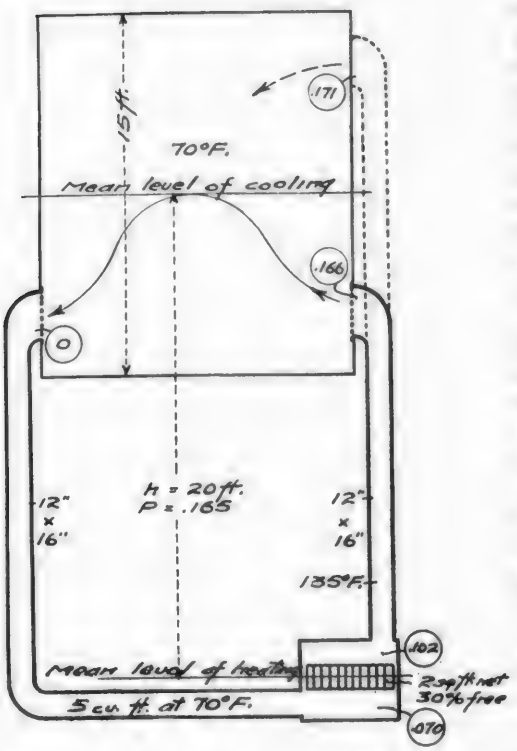


FIG. 5.—DIAGRAM OF INDIRECT HEATING SYSTEM, WITH CLOSED CIRCUIT.

resistance. While no outside influences interfere, some delivery is always assured with this arrangement, whether specially calculated or not, but the volume will depend on the size and run of the air passages. A fair approximation may be obtained by estimating the total head available, the theoretical velocity corresponding to it and from the same the actual speed as a percentage, according to the circumstances. This method is proper for preliminary sizing and will answer for a single room and flue. The situation changes, however, with open circuits, for several rooms at unequal distances and probably with unequal back pressures. The study of the various factors and systematic calculation becomes vital in such cases.

When the circuits are interrupted, as in the case of Fig. 6, which represents the typical arrangement, care must be taken that the room will be under the same pressure as would be maintained with a return flue, that is, the atmospheric. This means that the capacity of the escape or vent must be equal to that of the return or heat flue. The example illustrates the effect of back pressure and suction on the height of draft and gives an idea of what might take place when no outlet is provided. The resistance to leakage is a most uncertain quantity at best and delivery may be stopped altogether when this leakage is counteracted by wind pressure. Proper vent capacity, figured, as indicated, from the height and temperature difference, will assure neutral conditions.

It is evident that not only the delivery must be equalized, but the means of escape as well. It is further essential to equalize the pressures that may disturb from the outside, through inward leakage and pressure on the intakes. This is done, for instance, by giving the intakes the same exposure as the windows of the rooms in question, so that the excess pressure is counterbalanced and likewise any suction effect.

It is only by considering these various forces and through systematic calculation that a fair distribution of warm air, the most fickle of all heat carriers, is approximately secured. Faulty delivery can, of course, be cured in various ways, by adjustment and concentration on the more important rooms, by raising temperatures and other ways of forcing, but

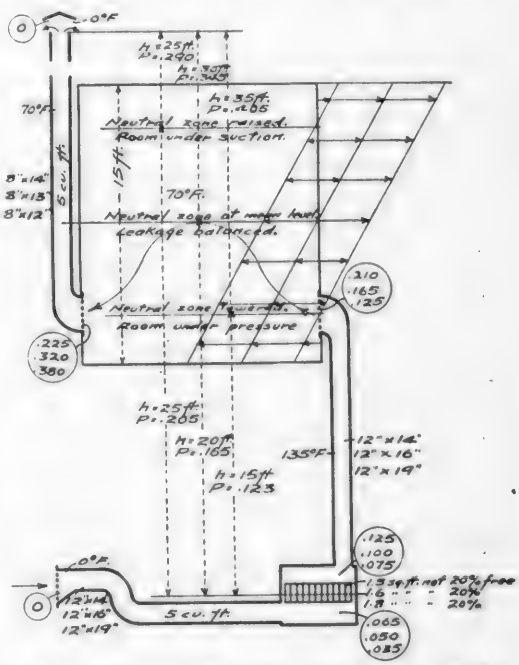


FIG. 6.—DIAGRAM OF INDIRECT HEATING AND VENTILATING SYSTEM, OPEN TO ATMOSPHERE.

these makeshifts generally involve loss of time, vexation, and cause heat losses which at times may be considerable.

It is sometimes argued that it is useless to calculate where so many factors are uncertain and beyond control, but just because there are elements which cannot absolutely be controlled it seems all the more important to control and take advantage of the forces as far as they can be made to serve.

IMPORTANCE OF CORRECTLY SIZING GRAVITY VENTS.

Gravity vents can likewise be planned on a scientific basis which will reduce its uncertainties. The consideration of the various factors will lead to the recognition and suppression of the disturbing elements. It will show the possibilities and also the limitations of gravity systems.

A common practice, for instance, is the terminating of vent flues in the attic space and trusting to leakage for final escape. The leakage in such spaces is generally considerable, but so, very often, is the volume to be exhausted. An unknown back pressure will exist and is apt to be increased at times by inward leakage under wind pressure. The scant power for updraft in some of the flues is likely to be offset and when some of these vents and the attic itself are exposed to cooling a reversal of action is to be expected and need not cause surprise under such conditions.

Back drafts are not only annoying but positively harmful in certain cases. Vent flues carried to the atmosphere are justified and proper for this reason alone. They are also recommended for mechanical efficiency. They can be made to terminate so that wind action at the top is neutralized and will incidentally avoid the extra loss of head and resistance entailed by discharging into and out of the attic, thereby utilizing the available power as far as can be done. When cooling of the flue is avoided, there need be no fear of reversed action.

In hot blast heating and mechanical ventilation the results are by no means assured merely through the application of power, as everyone with some experience will admit. It is recognized generally that certain proportions of conduits are essential for good distribution. Some engineers are designing air ducts for an even rate of pressure loss, giving a gradual reduction of velocities as branches are taken off. This method, if nothing else is done, gives a fair approximation for estimating purposes. It facilitates also the final, more accurate equalization which tends to avoid the necessity of adjustment after installation.

This result can be obtained with careful design and supervision and is an advantage, as those will appreciate who have put extensive ventilating systems into operation. The difficulties of obtaining even delivery increase greatly with the size and complexity of the plant. The wind pressure often causes fluctuations of discharge and sometimes the temperature influence changes also during the tests, so that one may have to start all over again repeatedly before a satisfactory showing is made. Even then the results are not permanently secured, since the adjustments, when not perfect, are most liable to be upset again by incompetent parties.

The careful design and calculation of conduits with a view of equalizing pressure losses is, therefore, most desirable. It will save many dampers, as well as the temper of the operator, and will also avoid the tampering that may discredit the plant. It will also save friction and power, not so much through the avoidance of throttling, as through the fact that the process of equalization will force the designer to ease the flow of air in main ducts and extreme end branches in order to get results. Also, the question of resistance and power is always kept before him. He cannot help seeing the chances for getting along with a certain size of motor, if it can be done by easing air passages.

One of the best opportunities devolving from systematic calculation lies in the avoidance of losses of motion through sudden changes in speed and direction. The entrance and the exit of a fresh air or heating chamber in itself, for instance, often will prove to be a considerable item of energy quite uselessly expended. A continuous, well-shaped duct connection from the intake to the stacks and from the stacks to the blower, with a taper at the outlet gradually reducing the speed

at the outlet, may save a material loss of pressure. When consistently applied throughout an apparatus, this principle will result in a substantial increase of volume that may be handled by a given size of fan or a decrease in speed and motive power.

Further gains can be made by appropriate shaping of branch pieces to suit the static and dynamic pressure in the duct. Sharp angles and sudden contractions should be avoided, particularly where the speed is high, but the high velocity does not necessarily involve great local resistances. It is possible even to increase it considerably beyond that of the mains and when necessary to get through a tight place, it can, as a rule, be done with little loss. It is merely a matter of shaping the passage in the proper way and knowing how far the area can be reduced in a given situation.

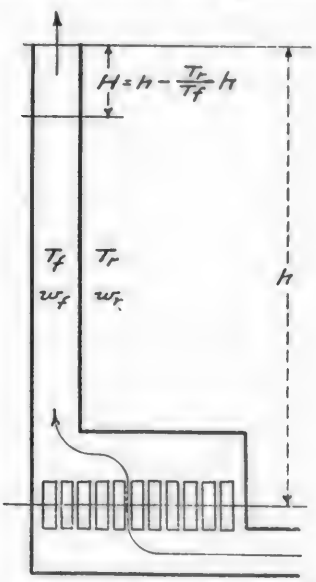


FIG. 7.—DIAGRAM SHOWING EFFECTIVE HEAD OF HEAT FLUE.

The total pressure at the point in question will give the theoretical speed corresponding to it and the orifice for the volume to be handled. If the speed is increased gradually by easy contraction, kept within the theoretical and decreased again still more gradually by nozzle shape, such obstructions as occur in the course of installation can be overcome without causing an appreciable increase of pressure.

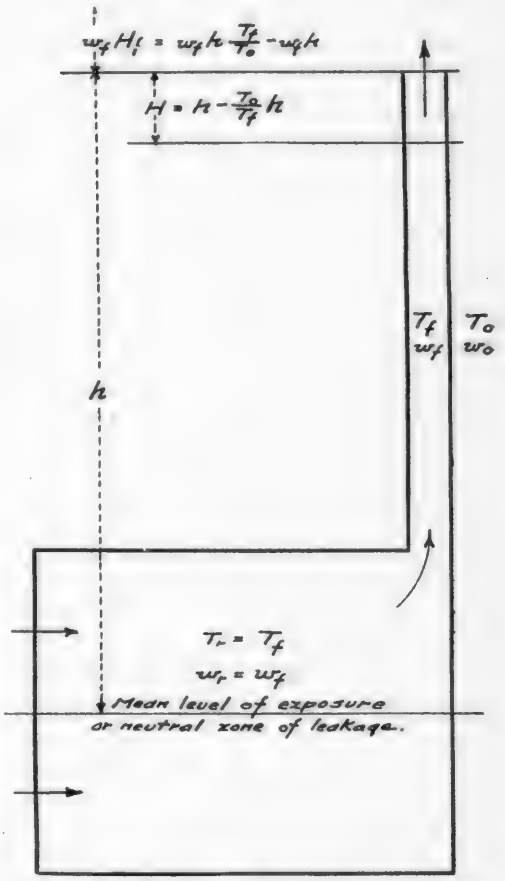


FIG. 8.—DIAGRAM OF EFFECTIVE HEAD OF VENT FLUE.

CORRECTLY-DESIGNED AIR DUCT SYSTEM SELF-CLEANING.

Aside from the mechanical advantages of keeping up the steady forward motion and avoiding all sudden changes in speed with backward currents or eddies, the idea is of distinct hygienic advantage in that a duct system can be made practically self-cleaning in this manner. Dust will collect and settle only in dead spaces. If these are avoided altogether, which is a reasonable, practicable requirement, the system cannot gather dirt during operation and can easily be flushed after periods of lying idle.

The principles of good distribution are brought out plainly in the calculation of air ducts, whereby the static or steady, radial pressure and the dynamic pressure, or live force of the air current, must be observed. A large drum or trunk line wherein the static pressure is

kept up well throughout is most favorable for that purpose, but is generally too cumbersome and too expensive. Small mains, on the other hand, make it difficult to equalize. The high speed at breechings increases the uncertainties, especially at or near elbows. It is best to keep the mains as ample as conditions may permit.

When the total head is determined and the speed at the outlet of the blower given, the performance of the latter is also defined by the corresponding static and dynamic head to be produced. A type of fan may then be selected by the engineer or manufacturer that will suit these pressures and give the highest efficiency. The efficiency of blowers is not altogether a matter of design and type, but depends also on the adaptation. Designers of blast systems should, therefore, consider the efficiency of the outfit as a whole, which may be affected materially by their own work in laying out the conduits and determining the power needs.

The engineer's work tells in the same way on other problems in heating and ventilating. More or less efficiency is attainable, not only in pumping water, but also in gravity systems and in the handling of steam, even though it cannot be expressed in percentages. Just as the mechanical engineer has succeeded in producing a highly efficient steam engine (in one sense, at least) also nearly perfect water turbines and other prime movers through scientific work and, in a great measure, through the skillful handling of the fluids, so it seems possible to profit by applying mechanics to the handling of water, steam and air. It does not bear exactly the same relation to it and is not the whole of the problem in heating and ventilating work, but an important part of it. The distributing ducts and pipes are the arteries supplying the current of life. Poor circulation makes a man liable to disease. It reduces his efficiency and puts a handicap on all effort. Likewise, good circulation is a prime condition for a healthy heating job and should have the best attention.

(THE END.)

Chart For Determining Size of Pipe for Gravity Hot Water Heating Systems

By M. S. Cooley.

A remarkable chart for gravity hot water heating work, by which the many variables involved in the calculations can be easily traced and the proper size pipes determined by simple methods, was presented by M. S. Cooley, of the Supervising Architects' Office, Washington, D. C., at the recent meeting of the Heating Engineers' Society in Buffalo, N. Y., and is presented herewith:*

(In the description of his chart, Mr. Cooley gave the calculations from which his formulas were derived. The chart is plotted on the basis of the temperature of the water entering radiator being assumed at 180° F. and the rate of transfer of heat from the radiator to the room as being 1.8 B. T. U. per degree difference in temperature between the water in the radiator and the surrounding air.)

INSTRUCTIONS FOR USE OF FRICTION DIAGRAM IN CALCULATING SIZES OF HOT WATER HEATING PIPES.

One-Pipe System, Main in Basement.—Radiator tappings, branches and risers. First ascertain the distance from the bottom of the flow main to the top of the radiator. Find this number at the base of the chart and follow vertically to the intersection of the line inclined toward the left near the top of the chart corresponding to the difference of temperature desired between flow and return connections to the radiator. Now

*A full-size chart, approximately 17 x 21 in., from which the accompanying illustration was made, is available through the American Society of Heating and Ventilating Engineers to readers who would like to procure a copy for their own use, at 25 cents each. The charts are made by a special process and are known as inkographs. They are suitable for framing and should prove valuable to the heating engineer or contractor who is called upon to design gravity hot-water heating systems. Those desiring one or more copies may procure them by addressing the secretary of the society at 29 West Thirty-ninth Street, New York.

follow the horizontal line passing nearest to this intersection toward the left until it intersects the dotted line inclined toward the left, and corresponding to length of connections from main to radiator and back flue:

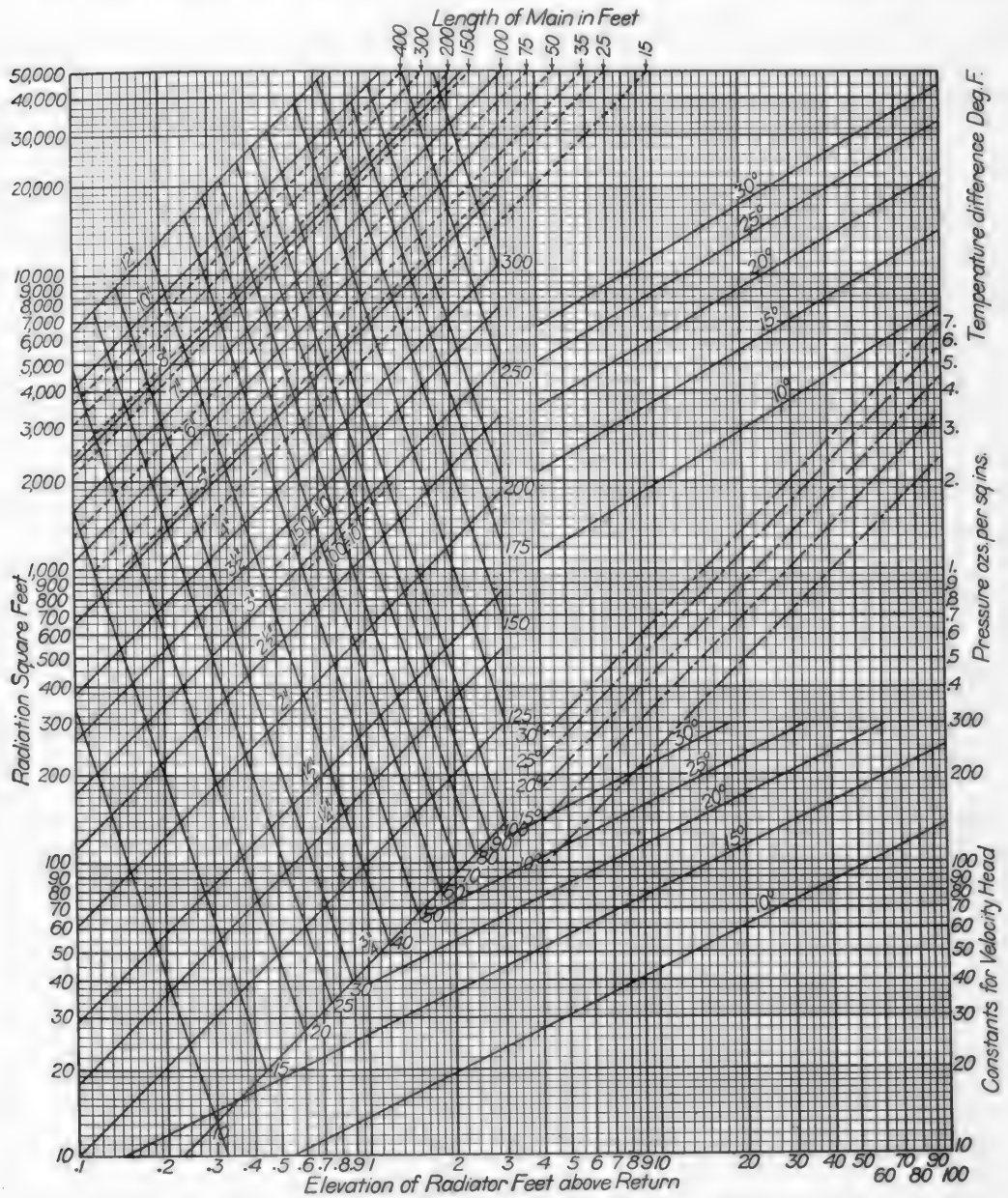
For each long turn elbow or gate valve, 5 ft.

For each short turn elbow or angle valve, 10 ft.

For each globe valve, 20 ft.

Now follow the vertical line, passing nearest to this intersection to its intersection with the horizontal line opposite the figure in the left-hand margin corresponding to the amount of radiation to be supplied, and the solid diagonal line inclined toward the left that passes above this intersection is the size of pipe required.

Example: Elevation, 6 ft.; temperature difference, 15°; equivalent length,



PIPE CHART FOR GRAVITY HOT WATER HEATING.

50 ft.; radiation, 100 sq. ft. What size pipe required?

Follow line from "6" at base of chart to intersection with diagonal 15°. They intersect on horizontal line "2800"; then follow line "2800" to intersection with dotted diagonal "50." They intersect on vertical line "0.26." Follow this to intersection with horizontal line "100." The solid diagonal inclined toward the left above this intersection is "2 ins."; therefore a 2-in. pipe will be required.

We have still to determine the head necessary to produce this velocity. To obtain this find the diagonal line inclined toward the right passing nearest to the intersection of diagonal "2" and horizontal "100." This is "10" or "constant for velocity head." Follow horizontally from the figure in the right margin near the bottom corresponding to this constant to its intersection with the lower diagonal 15°, and the head to produce this velocity is found in the lower margin and in this case is 0.14 ft. This must be added to the friction head. In nearly all gravity work this velocity head is so small it may be neglected.

If we wish to know the pressure in ounces per square inch equivalent to this head and temperature difference, follow the horizontal "6" to its intersection with the broken diagonal 15° near the center of the table. Then follow the horizontal line to the right margin, where the pressure in ounces per square inch is found to be 0.2.

To ascertain size of main, use the distance of the flow main at its lowest point to the bottom of the boiler as elevation, and the length of the main from the boiler back to same plus allowance for elbows, valves, etc., as equivalent length. Use a drop greater than that assumed through radiator, and proceed as explained for radiator.

For Two-Pipe, Reversed Circulation System.—With flow main, in basement, measure total water travel from the boiler to the first story radiator and back to the boiler, plus allowance for fittings as equivalent length. Use the distance from the bottom of the boiler to the top of the first floor radiator as elevation. Ascertain sizes for the first floor. In a like manner ascertain sizes for the second floor, third floor, etc. Now combine these sizes into a single pipe having equal carrying capacity, in the following manner:

Note the figure on the left-hand margin, corresponding with the intersection of the diagonal for each pipe size. Take the sum and note the pipe diagonal, intersecting margin at said sum as size desired.

Example: 2=1 in.; 3=1¼ in.; 1=1½ in. Find pipe of equivalent carrying capacity.

Pipe, Ins.	Intersection		Number		
1	10	x	2	=	20
1¼	18	x	3	=	54
1½	29	x	1	=	29
2½	110	x	1	=	size required.

This neglects velocity and is permissible for gravity work only. If the system is not laid out to give equal water travel to each radiator then ascertain the pipe size for each equivalent length and find the pipe of equivalent carrying capacity to the sum of pipes it serves.

Often we have two pipes to equalize, neither of which is fully loaded, and if we equalize as in the foregoing we get too large a pipe. In such cases, and it is better in all cases, to run imaginary lines from the intersection by which pipe size was determined, parallel to the pipe size diagonals to the margin and add the quantities so found to determine the equivalent pipe size.

Example:

Elevation 6 ft.
Temp. difference 15°.
Length 50 ft.
Radiation 100 sq. ft.
2-in. pipe required.
Elevation 20 ft.
Temp. difference 15°.
Length 75 ft.
Radiation 100 sq. ft.
1½-in. pipe required.

If we combine a 1½-in. and a 2-in. pipe we get 29 + 62 = 91 = 2½-in. pipe.

If we project imaginary diagonals we get 23 + 39 = 62, or a 2-in. pipe is sufficient.

By noting the intersection of the imaginary diagonal with the margin at each determination, as well as the pipe size,

the combining can be quickly and correctly accomplished by addition of these notations.

Overhead System, Single Pipe Drops.—Use one-half the vertical distance from the flow main to the bottom of the boiler as the head. Make drops the same size for the entire length and large enough to supply the total radiation on such drop. Use temperature difference for system divided by number of stories heated as temperature difference for each radiator in determining size of radiator connections. Use total water travel from the boiler back to the same, plus allowance for elbows, valves, etc., as equivalent length. If all drops do not have the same water travel determine the size of the main to supply each drop separately and combine, as hereinbefore directed, to determine the size of the main.

Overhead System, with Double Pipe Drops, and Drop Insulated.—Use the distance from the top of the radiator to the bottom of the boiler as the elevation for that radiator, and the total distance from the boiler to the radiator back to the boiler, plus allowance for elbows, etc., as the equivalent length. Ascertain size of pipe for each story separately and combine into pipe of equivalent capacity. If all drops do not have the same water travel determine the size of the main to supply each drop separately and combine to determine the size for the main.

In event the drops or risers in any system are exposed in the rooms there will be a certain amount of cooling in the risers, which is hard to determine. This will tend to aid circulation in an overhead system and retard circulation in a system with flow mains in the basement.

The Primary Physiological Purpose of Ventilation

TO FACILITATE THE MAINTENANCE OF THE CONSTANT TEMPERATURE OF THE BODY.

BY THEODORE HOUGH,

Professor of Physiology, University of Virginia.

(Read at the Fourth International Congress on School Hygiene, Buffalo, N. Y., August 27, 1913.)

The study of the subject of ventilation* during the past few years has resulted in drawing a sharply marked line between two different but not mutually exclusive explanations of the mode of action of the air of an inhabited room.

The first of these explanations regards the effects of inadequate ventilation as an intoxication of one kind or another i. e., a harmful effect upon the organism of some material added to the atmosphere of a room from the bodies of those inhabiting it. It is unimportant, for purposes of classification, whether this material comes from the lungs, mouth or nasal cavity, or from the skin; or whether the poisoning is of the kind shown in ordinary pharmacological actions like those of strychnine, or digitalis, or whether it involves an anaphylactic reaction. The essence of the theory is that we are dealing with the poisonous action of some foreign constituent of the air on the human body.

According to the other explanation the air of a badly ventilated room reproduces the atmospheric conditions of a warm, calm day of high humidity, and the effect of poor ventilation is primarily and largely due to the combination of high temperature, high humidity, and deficient movement of the air about the bodies of those in the room. That these physical conditions of the atmosphere are harmful no one will deny, nor can anyone doubt that the badly ventilated room does produce effects which closely resemble those of a sultry day. It is, however, as we shall see, still a fair question whether the physiological effect of

*In this paper we assume that the initial atmosphere of the inhabited room consists of pure air of normal humidity, and deal with the physiological action of this initial air when changed by the presence of human beings in the room. Such conditions as the lowering of the relative humidity by heating cold air are supposed to be remedied before the air is supplied to the room.

bad ventilation and of a sultry atmosphere are essentially identical.

POISONOUS ACTION OF EXPIRED AIR NOT PROVEN.

What, then are the salient features of experiments bearing upon these two explanations? In the first place it is fair to say that all efforts have failed to demonstrate in the air of a badly ventilated room a foreign constituent *which exerts a poisonous action upon being taken into the lungs with the inspired air.* Carbon dioxide must be definitely acquitted of any such action. As to other constituents, it may be said that, although the odor of the air of a crowded room is sufficient evidence of the presence of foreign matter, the experiments supposed to show that this foreign matter, organic or inorganic, when rebreathed is poisonous, have failed of confirmation when repeated under properly controlled conditions. In this connection attention should be called to the fact that harmful results obtained by the subcutaneous injection of material obtained in one way or another from a vitiated atmosphere do not prove that this air is capable of poisoning the body when it is rebreathed, nor is it an ultra-refinement of logic to say that the only acceptable proof that the bad effects of poor ventilation are due to the poisonous action of foreign constituents is to reproduce these effects by *rebreathing the foreign material* in concentrations in which they occur in the room, and with other unfavorable concomitant atmospheric conditions of such rooms excluded. It is not too much to say that no such proof has yet been given.

These considerations apply to the very striking experiments of Rosenau which show that, when the air of a confined space inhabited by one animal is cooled so as to condense certain substances out of it, subcutaneous injection of this condensed material sensitizes another animal so that a second injection of the blood serum of the first animal produces an anaphylactic reaction. These experiments are very important, for at present they constitute the only evidence in our possession of the existence of poisonous material in the air of an inhabited room; but attention must be called to the fact that the anaphylactic reaction has not been produced in a sensitized animal by rebreathing the vitiated air. Until this is done we are not justified in accepting this as the solution of the problem before us. We take this position at the same time that we fully recognize the suggestiveness of the work and express the hope that future experiments along this line will contribute materially to the solution of the physiological problem of ventilation.

ANALYSIS OF A "SULTRY" ATMOSPHERE.

The role of the physical conditions which we sum up under the term "sultry" atmosphere in producing the effects of poor ventilation is indicated by numerous observations and experiments. I have already cited in another paper the experience of a friend of mine in ventilating a crowded lecture room. He found that no complaints of bad ventilation came if he kept the temperature of the room at 68° F. by forcing in cold air, but had such complaints if the temperature was much above 70° F., although it often occurred that the actual amount of outdoor air supplied in the latter case was greater than in the former. It is significant, too, that these complaints were not usually of the temperature of the room but of its ventilation. It would be a fair reply to this to say that it is only when the room temperature rises above 70° F. that perspiration begins to be secreted by the sweat glands and that the "crowd poison" may be some material volatilized from the perspiration. Here the cabinet experiments add to our exact knowledge.

When one or more persons are enclosed in a comparatively small air-tight cabinet and thus exposed to the vitiated air which gradually accumulates therein, there is experienced sooner or later and often in very intense form the effects of inadequate ventilation. But these effects can be lessened or delayed, by any one of three means: (1) by absorbing the excess of water vapor; (2) by the use of an electric fan; or (3) by preventing the rise of temperature of the air of the cabinet.

A combination of any two or of all three of these procedures is more effective than is any one taken alone. Flugge and his pupils have, moreover, found

that if by the use of a nose or mouth piece provided with suitable valves, the subject within the cabinet breathes the pure air from outside the same results are obtained as when he breathes the air of the cabinet. In this form of experiment the subject is not breathing the "crowd poison," although the surface of his body is exposed to the sultry atmosphere of the cabinet. On the other hand, if the subject of experiment remains outside the cabinet but breathes (through the nose or mouth mask) the air of the cabinet vitiated by the presence of a second person no bad effects are felt. While it is fair to urge that these experiments are lacking in any objective test and that the subjects of the experiments may have mistaken their feelings of discomfort for the effects of bad ventilation, yet the fact remains that *they record no ill effects whatever when the physical atmospheric conditions to which the skin is exposed are kept ideal, even though they are breathing into their lungs a highly vitiated air.*

If bad ventilation acts solely or chiefly by the poisonous action of a foreign agent in the atmosphere, why were no ill effects experienced when the subjects of these experiments were exposed to this hpyothetical "poison"? I see no answer to this except that conscious or unconscious leaning toward a certain theory made the subjects incapable of correct observation. I can only say that on the basis of my personal experience with certain cabinet experiments I am inclined to give little weight to this explanation of the results.

It will assist toward the practical solution of our problem if we consider certain objections which have been raised against the theory we are now considering. We are peculiarly liable to regard the problem of ventilation as a simple problem, involving only a single factor of at most a group of cognate factors; while, as a matter of fact, it may be a problem involving several factors of very diverse character. Hence an objection nothing more than an indication that the problem has been only partially solved, may be mistaken for a conclusive argument against the solution.

IMPORTANCE OF PSYCHIC EFFECTS.

The first objection I shall consider is that many persons find the effects of a sultry day qualitatively different from those of bad ventilation. These subjective differences, however, may be partially if not largely due to the well-known individual variations in the sensitiveness to odors; for if the odor of "polluted air" produces unfavorable effects, it becomes a real factor in the physiological as well as the practical problem of ventilation. It makes no difference whether the effect is entirely "psychic," for a psychic effect is as real a thing as a toxic effect; and it would be the height of absurdity to say that we should not provide for the person who suffers from these psychic effects of the odor of the air. We will all admit, then, that the air must either be renewed, or purified in the process of recirculation.

But to admit the reality of these effects is by no means to say that the physical conditions of the atmosphere as above outlined are not of primary importance in the problem of ventilation. The writer of this paper is most unfavorably affected by the odor of the air of a badly ventilated room whenever he is conscious of it; indeed, the effect in his case can properly be described as a very real physical depression; and yet he has remained without any discomfort whatever for an hour in a closed cabinet, the air of which had an overpowering odor to the attendant upon opening the door. The subject of experiment was unconscious of the odor and it did not influence him. In this same series of experiments, unless the temperature was kept down to 70° F. and excessive humidity prevented, marked discomfort was invariably the result; and this discomfort was essentially the same as that experienced in a poorly ventilated room or on a warm muggy day in summer.

CONTINUOUS MOVEMENT OF OUTDOOR AIR.

A second objection is that out-of-doors a stagnant, humid atmosphere does not become particularly uncomfortable at a temperature of 73-75° F., whereas the badly-ventilated room of this temperature is distinctly oppressive. But there is usually one great difference between the two cases. In the crowded room there is rarely any considerable movement of air about the bodies of those in the room; on the other hand it is

distinctly the exception to have no breeze whatever on a sultry day out of doors; and even in the house we usually get some movement of air by opening windows and doors. Now it is precisely the formation of an "aerial blanket" about the skin which is a most important, if indeed it is not the most important source of trouble in the crowded room. This aerial blanket acts, of course, by interfering with the loss of heat from the body, by diminishing both convection of heat and evaporation of perspiration; and I doubt whether anyone sitting still out-of-doors on a perfectly calm, muggy day of 73° to 75° F. temperature would fail to note at least the partial correspondence between his discomfort and that which he experiences in a crowded room. It must not be forgotten that it requires only a very slight movement of air to get rid of the aerial blanket; less, in fact, than would ordinarily be dignified with the name "breeze." This is generally present on the sultry day, especially out-of-doors; it is usually absent in the crowded room.

I think that in stating this atmospheric aspect of ventilation this factor of air movement has been neglected in our attention to the factors of temperature and humidity. It is not any one, nor any two of these alone which must be watched. It is all three, and this because all three have the common result of raising the temperature of the skin, thereby introducing into the body the conditions which lead to discomfort, lassitude, headaches, etc.

WHY A VAPOR BATH IS STIMULATING.

A third objection which has been urged against the theory is that the vapor chamber of a Turkish bath presents the combination of lack of air movement, high humidity, and high temperature; and yet, while exposed to this atmosphere, we do not experience the depressing effects of bad ventilation; on the contrary, the vapor bath is stimulating. This objection is certainly not well taken. A temperature of 129° F. or more produces very different physiological effects from those produced by a temperature of 75°-100° F. It is well known that hot water stimulates both the nerves of heat and those of pain, and that in the stimulus from very hot water that of pain preponderates; and the same thing is true of hot, moist air. Possibly, too, the elevation of body temperature may also contribute to the stimulating result of the Turkish bath. That the physiological effect of high temperature (*e. g.*, 120° F.) differs qualitatively, and not simply quantitatively, from that of lower (*e. g.*, 90° F.) temperatures is also shown by the fact that a lukewarm bath generally lowers arterial blood pressure, while a hot bath generally raises it. Probably the explanation of the effect of the higher temperature in both cases is the introduction of a new physiological complex through the afferent channel of the nerves of pain. It should also be remembered that, as shown by Head and Rivers, there are two groups of afferent nerves included under the "heat nerves"; the epicritic fibres, whose end organs respond to any elevation of the temperature of the skin, and the protopathic fibres, which respond only to temperatures of 37° C. and higher. The specific reflex connections of these two groups of fibres have not as yet been investigated; but it is quite possible that this also plays some role in the different effects of moderate and strong heat stimulation. At any rate enough has been said to show that the objection in question is not at present logically valid.

Summing up the main points of the foregoing discussion, it would seem fair to say that there is at present no conclusive proof of the presence of a toxic agent in the air of a crowded room, but that the possibility of this is not excluded. The effect of inadequate ventilation is probably a complex matter in which several factors contribute to the result. We know and must reckon with some of these factors, while probably others are as yet unknown. Two at least seem to be established, namely, the influence upon the organism of conscious sensations of smell, and the unfavorable circulatory and other adjustments forced upon the body in order to maintain its normal temperature under the atmospheric conditions of high temperature, humidity, and stillness. It is, moreover, probable that the influence of these several factors varies with different individuals, according to

their sensitiveness to disagreeable odors, the thickness of their subcutaneous layer of fat, or the intensity of their reaction to the atmospheric conditions in question. It is also modified by a psychic factor; for the man or woman who firmly believes in the existence of "crowd poison" and who consciously or unconsciously identifies this crowd poison with the odoriferous foreign matter will suffer ill effects as soon as he becomes conscious of the odor, even though the physical condition of the atmosphere may be ideal; on the other hand, the man who is not worried by the odor of the air or the man who is unconscious of it may notice no ill effects in the same room. The influence of inadequate ventilation no doubt also differs according to what one is trying to do when exposed to it. It may be negligible in the case of one doing a routine, mechanical task, but very marked in another whose work requires close attention and accurate thinking.

If the writer seems to appear in the role of a partisan of the view that the problem of ventilation is *primarily* a problem of the mechanism of temperature regulation of the body, this is not because he would belittle other possible factors, far less close the door to further investigation; but rather because he believes that everything indicates that this factor is of prime importance; that it is invariably present in a poorly ventilated room; that it inevitably affects unfavorably every inhabitant of such rooms; and that it must be cared for in practice, no matter what else we may try to accomplish. Any practical efforts at ventilation which neglect it are sure to fail and those which provide for it are sure to be at least measurably successful.

In other words, it is a real advance in the practical hygiene of our subject to recognize that the primary problem of ventilation is not the removal of poisonous material which would otherwise be breathed into the lungs, but the maintenance of the physical conditions of that portion of the atmosphere in immediate contact with the surface of the body in such form as will place the minimum burden upon the mechanism of temperature regulation.

In the above discussion we have not touched upon the very important question of the physiological action of these unfavorable atmospheric conditions, for it is not possible to treat them within the limits of this paper. Doubtless this physiological action is complex, consisting partly of undesirable changes in the distribution of blood whereby certain organs are deprived of their normal supply in order to rush all the blood possible to the skin; partially to the conscious discomfort of an overheated and moist skin; and partially to some as yet imperfectly understood effect upon the oxygen-carrying function of the blood. Especially suggestive are the observations of Barcroft and his co-workers on the effect of moist heat upon the dissociation curve of blood. (Journal of Physiology, 1913, XLV, p. xlvii.)

PRACTICAL APPLICATIONS OF THEORY.

In conclusion, let us consider some practical applications of the theory that the physiological problem of ventilation is primarily a matter of the mechanism of temperature regulation in the body.

1. When the temperature of the atmosphere about the surface of the body is kept at about 68°-70° F. the problem of ventilation is largely solved. "Foul air," *i. e.*, air having a distinctly disagreeable odor, must of course be removed; but at this temperature the unpleasant odors seem to be less intense, probably because of the smaller secretion and evaporation of the perspiration.

We may call this the critical room temperature, for it is the dividing line between those temperatures at which the body becomes chilly and those at which it must take active measures to get rid of the heat necessarily produced in its life processes. The correction of too low a room temperature is the problem of heating; the correction of the conditions above this critical temperature is the primary problem of ventilation. So long as the room temperature is kept at the critical point, humidity and air movement are negligible factors, so far as the regulation of the temperature of the body is concerned. Renewal of the air is necessary, but the less draft produced in accomplishing this the better. This

statement, however, holds true only for this critical temperature.

2. If it is not possible to keep the temperature of the air immediately about the body at 68°-70° F., the first recourse must be to those measures which favor the prompt evaporation of the perspiration. To be strictly accurate, it is not the temperature of the air immediately about the skin, but the temperature (and perhaps the water content) of the skin which determines the comfort or discomfort of the subject. Air at 85° F., if fairly dry and in motion, may, through the effective evaporation of the perspiration, keep the skin at the same temperature as comparatively still air at 70° F. In other words, the two cases present identical physiological conditions, although this physiological condition results from very different physical properties of the air immediately about the body. Consequently in practical ventilation there are two rules to follow at room temperature above 70° F. The first is to keep down the humidity of the air as much as possible; the second and more important is to keep the air about the body in motion; if, in doing this, it is renewed, so much the better. The first requisite on hot days is a breeze; and the most important practical problem in the ventilation of a crowded room is to secure this breeze, *so as to maintain the temperature of the skin at the optimum point, i. e.*, the point which it has in a comparatively dry atmosphere of 68°-70° F. when the subject is at rest. Sometimes this is best secured in one way, sometimes in another. Thus, if cool air can be admitted from outside it is better to open windows wide or in other ways to admit this air. If, on the other hand, the outside air is very hot, it is better to admit it only sparingly and depend upon electric fans to produce the essential movement of air.

To put the same thing in another way: On a hot (*e. g.*, 90° F.) day a room may be better ventilated when its temperature is kept down by opening the windows only enough to secure moderate renewal of the air and keeping the cooler air within in movement by the use of fans—even though the renewal of the air be very imperfect—than it would be when the air is thoroughly renewed by sending in large quantities of hot and perhaps humid air from outside. In this and all similar cases the first thing to make sure of in meeting the problem of ventilation is not the renewal of the air breathed, but the maintenance of the temperature of the skin as nearly as possible at what we have called the optimum point. At 68° F. no great amount of movement of air is needed; indeed, it is not desirable; at 80° F. it is necessary; and for precisely the same purpose in the two cases, in order to maintain the proper skin temperature.

Finally, to avoid misunderstanding, it must be distinctly understood that we only assert that the regulation of these atmospheric conditions which come into relation with the mechanism of temperature regulation in the body are of first importance; we do not assert that this alone is important. We simply insist on this as something which must not be neglected—indeed, must be first attended to in practical ventilation; and we insist upon this without in the least denying that other factors may and do need attention.

A chart showing the regulation of school house construction in the United States up to December, 1912, has been prepared by Frank Irving Cooper, of Boston, and is published in the School Board Journal. This chart is supplementary to one published in THE HEATING AND VENTILATING MAGAZINE in April, 1911, and is interesting as showing the advance made since that time.

While in 1910, 24 States had no laws or regulations regarding regulating school house construction, at present only 18 States have failed to take such action. It is also to be noted that while in 1910 nine States placed the control of school house construction in the hands of their health departments, in 1912 ten States are doing so. There has also been an increase in the control by State departments of from 13 to 20 States, while Massachusetts and Ohio control through their State and police departments, and Kansas requires that building plans shall be submitted to the State architect. This has practically the effect of compulsory regulation.

At present Ohio has the most stringent law on the subject, while New York and Vermont lead in the completeness of their regulations.

The Architecture of Open Air Schools

WARMED FLOORS AN IMPORTANT FEATURE OF THE IDEAL BUILDING.

BY JOHN R. VAN PELT,

School of Architecture, Columbia University.

(Read at the Fourth International Congress on School Hygiene, Buffalo, N. Y., August 26, 1913.)

Unlike the architecture of the ordinary school where experiment has prescribed the type, open-air schools have not yet been built and tried out. Open-air school-rooms have been built or altered from old school-rooms as minor parts of buildings, roofs, covered and uncovered, have been turned to the purpose, but the complete school, planned in all its details toward the one end and of an advanced type, is yet to come.

THE IDEAL TYPE.

In describing the ideal conditions to which I think such a school should conform, I have in mind a type slightly less radical than what is sometimes known by the title, namely: a school that is entirely out of doors, with little more than a roof, and is typified by those at Shrewsbury House and Bradford in England. On the other hand, something that is considerably more open than what has been styled the low temperature school, such as the Graham School, or such schools as No. 21, in New York, where the rooms have been adapted from the regular type by merely changing the pattern of the windows and keeping them open.

In other words, I propose a building so constructed that the air in all parts of rooms where the children remain will be continually replaced by outdoor air that has only sojourned a few seconds within the limits of the building, yet not a building that is entirely without heat.

The ground for such a school should be sandy or gravelly, without too much clay, so as to preclude a humid condition in the entering air. It should be protected from the wind—pine, spruce, etc., forming an excellent screen; but these trees should not be too close to the building and should not cast a shade upon it. City schools should be so situated that sun will not be cut off from them by adjacent skyscrapers. This is also important because the high buildings of our later construction cause concentrated air currents that would render work in an open-air school almost impracticable, by blowing papers and material about and forcing dust and dirt up and through the school.

Toilets are to be placed so that odors cannot reach the open class-rooms. An unsanitary condition of this kind will become particularly objectionable in warm weather.

VENTILATION REQUIRED ON TWO OR MORE SIDES.

It is essential that the plan be so arranged that all class-rooms, study-rooms, the auditorium and wherever the children remain shall have ventilation on two or more sides, and to really fulfill conditions properly, the room should be open on at least two sides that are opposite each other. Corner rooms with windows on the sides perpendicular to each other may be satisfactory when there is a sufficient amount of wind; but when there is little movement in the atmosphere, a dead corner with eddies is likely to retain the air in certain portions of said rooms. On the other hand, if rooms are entirely open on two opposite sides without protection a storm or misty rain will carry completely across the room. For this reason an open gallery is advantageous.

GENERAL PLANS.

General plans may be divided into three classes: The "U" or "H" plan, where the wings are about open courts, the "T" or "Star" plan, where the wings radiate from a center, and the enclosed court plan. The last named is not so good, and all plans should so enclose the courts that the latter are open on at least one side which is not the north. This is to insure the entrance of the sun into all parts of the court during some part of the day.

I see no objection to building three stories high above basement or higher, if means of ascent can be provided. Open galleries and open staircases are good, provided they are protected from snow and sleet. A great advantage is that children passing between the cold rooms do not undergo a sudden change of temperature.

An objection to packing class-rooms on the ground floor is dust and odors from the street and the general impurity of the air.

FLOORS OF CLASS-ROOMS TO BE WARMED.

Class-rooms may have the floor warmed. This would slightly temper the air and keep the children's feet from becoming cold, tending to dry them if they had not come to school with rubbers. If the floor is heated it must necessarily be of a material that will not be affected by the heat. For this reason the warmed floor may be attained by metal plates separated by composition.

HEAT FOR COAT ROOMS AND TOILETS.

Coat-rooms should be well ventilated, but kept reasonably warmed, that is, about 65° F. This will appear quite warm to the pupils coming from the class-rooms and halls, and a higher temperature would be uncomfortable before the smaller children could succeed in adjusting their clothes. It may be suggested that coat-rooms could be omitted, in that the children wear about the same clothing in the class-room that they do out of doors. If they have to come to school through snow and storm, their outer wraps should be taken off and dry wraps put on, and I believe it would be better to provide a proper place to keep such wraps, allowing the damp ones to dry.

Furthermore, exceptional cases occur where fragile or aenemic children suffer from time to time from the cold. This has been noted in the Graham School reports, and the warmed cloak-room offers an excellent place where their vitality may catch up. Although limited space may seem to force wardrobes in the class-rooms, I consider it a bad solution. In such case a warmed room for recuperation should be provided on each floor.

Toilets must necessarily be warmed. In very cold weather plumbing pipes would freeze. A temperature of 60° to 65° F. is ample. Anything higher than this would be bad.

In laboratories, manual training rooms, etc., provision often has to be made to maintain such a temperature that liquids under study will not freeze, and where fine and delicate work is done the temperature cannot be allowed to go quite as low as where some protection for the hands may be worn in cold weather. Furthermore, below a certain temperature is not easy, and for some persons, not possible to perform very delicate work. Steam radiators should be introduced in such rooms, and if a number of small radiators are scattered about, the heat can easily be graduated by turning on one or more and allowing the others to remain empty. Provision must be made for draining these radiators rapidly.

Rooms for visitors should be provided where the temperature is not allowed to fall too low, and heat will probably be required in the principal's and teachers' rooms.

In spite of the fact that such a school is open and a considerable amount of heat lost, the fact that the average temperature of the building is kept so much lower than is ordinarily the case will probably show a slight saving in coal over the usual type of school house. Sufficient experiment along this line has not yet been made to definitely determine the proportion.

HEATING SYSTEMS LIMITED TO STEAM OR VAPOR.

Hot water systems cannot be used, owing to the danger that pipes and radiators may freeze. Hot air is useless, as it cannot be controlled in such a building. Steam or water vapor are therefore the only possible means of heating, and water vapor is hardly effective enough under the conditions that usually obtain.

Heating the floors of the rooms has already been mentioned. The floors should not be overheated. Chilblains would probably result to the children. In the cold rooms the steam that would form would probably be objectionable and a high degree of heat would cause odors. About 40° Centigrade is a maximum temperature for a floor surface.

Fourth International Congress on School Hygiene

Buffalo, N. Y., August 25-30, 1913.

The fourth International Congress on School Hygiene, held in Buffalo, N. Y., during the week of August 25-30, proved in many respects the most important scinetific gathering ever held in America. Over 2,000 delegates were in attendance. This shows a gain of more than 500 over the total attendance of any previous meeting, the registration at the congress in Paris having been 1,500. Delegates from twenty foreign nations were registered, as well as from every section of our own country.

The essential purpose of the Hygiene Congress is to familiarize the public, particularly parents of school children, with the modern methods of hygiene as applied to children in the schools. The papers read and the addresses delivered covered a multitude of topics, sixty being given at the various sessions of one day.

The subjects in which the most lively interest was shown were sex hygiene; the open air school; the heating and ventilation of schools; and various kindred subjects relating to the welfare of school children.

The session on "The Ventilating, Heating and Cleaning of School Buildings" occupied one entire day, being preceded by a round-table conference on Tuesday evening, where an informal discussion took place on the various phases of ventilation. This conference was presided over by Prof. C.-E. A. Winslow, of New York, and questions pertaining to the subject of ventilation were discussed by Drs. Gulick, McCurdy, Franklin, Sir James Kerr, and others present.

The first paper presented at the Wednesday meeting was by Dr. J. H. McCurdy, of the Y. M. C. A. College, Springfield, Mass., in which he described a series of experiments conducted at the college gymnasium. The ventilating apparatus is so arranged that the air may be recirculated and passed through an air-washer. Between 300 and 400 cu. ft. of air per minute per person is supplied, depending on the size of the class. It will be noted that this is about ten times the air ordinarily considered necessary for good ventilation. The system is considered highly successful, and, according to reports made by engineers who have studied the operation, results in a saving in fuel of approximately one-half as compared with using outdoor air. No trouble was noticed from odors when the air was recirculated through the air washer, nor did the CO_2 content of the air rise to an objectionable amount.

D. D. Kimball, consulting engineer of New York, presented a paper on "Some Phases of Ventilation," in which he reviewed and discussed the subject of ventilation, especially from an engineer's standpoint. This paper was followed by another, presented by Dr. Luther H. Gulick, of New York City, on "Recirculation and Ventilation." Dr. Herbert M. Hill, City Chemist of Buffalo, N. Y., spoke on "The Ventilation of School Building," describing the requirements and the methods of making tests used in his work in connection with the Buffalo schools.

The discussion on the preceding papers was opened by Dr. Kerr, of London, in which he remarked about the high temperature required in the American schools. In England the best temperature is considered from 55° to 60° F., and anything above 62° is found entirely too warm for the best results. A temperature of 60° and a relative humidity of from 50% to 55% is considered best by some English authorities. For schools in this country a temperature of 68° F. seemed to meet with the greatest approval, but the relative humidity conducive to the best results seems to be a matter of personal preference, and of local climatic conditions. Just what this is was not decided, although the general opinion was expressed that very low humidity was harmful, and high humidity becomes oppressive and therefore objectionable. In the Northern States during very cold weather, condensation will

form on the windows to an objectionable degree if the relative humidity is raised to from 45% to 50%. Some of the best results have been reported at from 35% to 45%, and 55% is generally considered the limit. A wet bulb temperature of 89° F. is said by some authorities to produce death in many cases, due to the rise in body temperature. It seems likely that this rise in body temperature due to high temperature and humidity were the cause of the terrible death rate in such cases as the "Black Hole of Calcutta," rather than excessive CO_2 or deficient oxygen.

At the Wednesday meeting, as well as at the round-table conference on Tuesday evening, it was conceded that the CO_2 content of the air is not a source of danger and should be considered of but slight importance. It may be considered much the same as the anemometer—merely an indication of the air change. Based on actual tests, with CO_2 far in excess of what is possible to obtain in an ordinary room, this gas has been shown to produce no injurious results. Ordinarily, due to infiltration and air leakage, the CO_2 content of the air in a room will not rise to an objectionable point, and in the experiments reported by Dr. McCurdy, with a gymnasium class of 70 men, the highest CO_2 obtainable ranged from 8 to 10 parts in 10,000 parts of air. The class was then quickly removed from the room, the doors closed, and the fans shut down. In a very short time the CO_2 had fallen to the normal amount, due to diffusion through the walls and to air leakage.

Although there was some question raised regarding the soundness of the reasoning, it was generally conceded that, due to the ordinary processes of respiration, there is no danger of the oxygen content of the air being reduced to a dangerous point. Dr. Gulick illustrated this point with the statement that "A horse can drink just as much out of a trough as out of a river," and contended that we need not be concerned either with the question of the oxygen or carbon dioxide of the ordinary room air. His opinion was that the only points to be considered are to have the air cool, of proper humidity, free from odors, and reasonably free from dust and dirt. While there is a great demand for *fresh* air, generally meaning outdoor air, the best authorities agree that outdor air is seldom *fresh* air or clean air, and that the only strictly fresh breathable air is that which has been washed and brought to a proper temperature and humidity by means of an air washer. This may be outdoor air or recirculated air, as the circumstances of the case determine. While ordinary odors are not considered necessarily poisonous or dangerous, they are at least unpleasant, and therefore objectionable, and if possible should be removed.

An important factor in good ventilation was to have the air in motion, without objectionable drafts. This aids in removing the air envelope about the body and so keeps down the body temperature.

While in an adjoining room a session was being held where the open air school was strongly advocated, it was the general opinion among the engineers and doctors present at this session that a school fitted with a fan system of ventilation properly designed, installed and operated, gave the best results for average normal conditions. The best modern plants are so installed that window ventilation can be used a part of the time if desired, without interfering with the ventilation of the other rooms or throwing the system out of balance.

A paper was presented by Prof. C.-E. A. Winslow, of the College of the City of New York, on "Studies of Air Conditions in the New York Schools." This paper quoted results from an extensive series of tests on the air conditions of schoolrooms, especially in regard to their bacterial condition. The tests indicate that there exists much less danger from bacteria in the air than has heretofore been considered to exist. A comparison of the results obtained at the various schools indicates that the best air conditions exist in buildings equipped with properly managed fan systems of ventilation; also that the buildings showing the poorest air condition were also equipped with fan systems, but improperly installed and managed. This paper was followed by a joint paper on "Air Washing as a Means of Obtaining Clean Air in Buildings," by Prof. George C.

Whipple and Melville C. Whipple, of Harvard University, Cambridge, Mass. (published in this issue).

The interesting series of experiments with recirculated air made by Prof. Frederic Bass, director of the engineering division of the Minnesota State Board of Health, as described at the recent meeting of the heating engineers' society, were explained in detail at this session. An air washer was installed in connection with a fan system of ventilation, arranged so that the air from the schoolroom could be recirculated. The supply ducts were so installed that there was a fresh air outlet at each desk in the room, giving each pupil a definite amount of fresh clean air. All odors were removed from this recirculated air by means of a small ozone apparatus, and it was stated that when the ozone supply was accidentally cut off there was a complaint from the teacher that something was wrong with the air in the room. Seven cu. ft. of air per minute per pupil were used in these experiments.

Prof. John W. Shepherd, head of the Department of Science, Chicago Normal College, also presented an interesting paper on "Some Experiments on the Ventilation of a Schoolroom," in which he gave the results of experiments made in Chicago in connection with one of the schools. Individual supply was used, something on the order of the system used by Prof. Bass.

The subject of ozone, and its use in connection with ventilation, was treated in two papers. Dr. Milton W. Franklin, manager of the Ozone Department, General Electric Co., New York, presented a paper on "Ozone in Ventilation." Due to the limited time this paper was not read in full, but some of the more interesting points were discussed. Prof. John C. Olsen, of the College of Engineering, Brooklyn, N. Y., then presented a paper on "The Purification of Air and Water by Means of Ozone."

The last paper of the session was read by Prof. Dr. Selter, Dozent für Hygiene, University Bonn, entitled "Heizung und Lüftung." Although this paper was read in German, it was followed by an interesting discussion, and the author was asked many questions in regard to the ventilation standards and conditions in Germany.

A feature of great interest to the visiting delegates was the exhibit in the Broadway auditorium of the scientific and commercial methods and appliances for teaching and carrying out the principles of hygiene in the schools. Those visitors, especially members of school boards, who are interested in the equipment of modern school buildings, were particularly attracted by the large-size working model of the carrier air washer.

Arrangements were made to hold the next congress in Brussels, Belgium. The president of the fifth congress will be chosen, according to precedent, from the country in which the meeting will be held.

Operating a Hot Water Heating Plant by Electricity.

The success of recent experiments in Tacoma, Wash., in connection with the use of electricity as a medium for operating a hot water heating plant has led to a permanent installation in the residence of George Franzenburg, in Tacoma, the architect being C. F. W. Lundberg.

In a report made recently to the city council, Superintendent of Light and Power B. W. Collins stated that the most successful method of using electricity for heating is in connection with a hot water heating system. By this method, electric coils are placed in the firebox instead of coal. The lighting department of Tacoma is now figuring on a suitable rate to charge for heating both houses and larger buildings through this arrangement.

Mr. Collins stated that the rate for electricity in Seattle is ½ cent per kilowatt hour, and he gave it as his opinion that this rate can be equalled and probably lowered in Tacoma. The council has authorized Superintendent Collins to experiment with electric heating in buildings of various sizes. One of the large department stores now being built will be made the base of one experiment.

The heating load on a hydro-electric power plant like Tacoma's is the most profitable of any. The current is taken at periods which are technically called "off-peak." During cold weather, when water is going to waste at the headworks, the heating load is the largest, and in the dry summer months, when low water may make it necessary to conserve every drop, the heating load is practically nil. Heat is also used during the day when the heavy lighting load is not "pulling."

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WHAT most people considered at the time a bold prophecy was that advanced two or three years ago by a heating engineer to the effect that the future of mechanical ventilation would have as its basis the purification and recirculation of the used air. He compared the general principles of the process to those now employed in the purification of sewage. This idea was generally decried at the time, yet it is now becoming clear that there is a substantial basis for his theory. For instance, three of the speakers at the recent International Congress on School Hygiene showed, either by tests or deduction, how the use of air washers, either alone or supplemented by ozone machines, had effectively purged the vitiated air of its objectionable qualities and rendered it fit for recirculation in occupied rooms. A notable case where this process was successfully adopted was that of the gymnasium of the Y. M. C. A. Training College, at Springfield, Mass.

These and other tests, which are described on other pages of this issue, call particular attention to the absorption by the air washers of the odors, as well as the dust particles, etc., contained in the exhausted air.

It is also our pleasure to present, in this issue, a discussion of the physiological aspects of the problem of ventilation which might easily be described as a logical explanation of the above-mentioned results. In this discussion, the opinion is advanced that the body temperature is the important thing in ventilation, and that since this can be maintained through moderate temperatures, renewal of the "aerial envelope" and the removal of odors and dust, the purposes of good ventilation are thereby secured. It has been shown that all this can be accomplished through recirculation with the proper appliances. These conclusions must, of course, await further substantiation, but the possibilities of such a method, while still requiring the same degree of engineering skill, are certainly alluring to the man who pays the bills in the way of reduced cost of operation.

WITHOUT doubt the most important conclusion brought out in the investigation, recently completed, of the air conditions in the New York schools is that referring to the carelessness often displayed by janitors in the operation of the plants. This, it is clearly shown, is the main reason for the storm of complaints regarding hot and stuffy conditions in New York schoolrooms. The solution of having the operating force under the control of the designing department has already been advanced, and in bringing this fact to the attention of the Board of Estimate the investigators have taken the most effective step possible to bring about this much-needed reform.

THE CONSULTING ENGINEER

"The Consulting Engineer" is prepared to reply, in this department, to any questions which our readers may ask regarding problems connected with the design and installation of mechanical equipments of buildings.

19. Heating Buildings of Sawtooth Construction.

QUESTION: Will you kindly answer the following questions in your consulting Engineering columns? What is the proper location of pipe coils for heating a saw-tooth factory building? Personally, I would say at A (see sketch) as that location will help the circulation. Others claim B is the better location, as it will prevent cold air falling. But does not this prevent the circulation desired? In general, with sow-tooth buildings of tight construction, used only 10 hours per day, is not a hot blast or blower system better than direct steam radiation?

SKETCH SHOWING LOCATION OF PIPE COILS IN SAWTOOTH FACTORY BUILDING.

ANSWER: Position B will be preferable to position A, especially in textile mills. The high humidity requirements in this class of work render the condensation of the water on the cold glass a serious matter. In some mills drains are provided to carry off the condensation and prevent the dirty water from falling on the products, where single glass is used. Double windows, with enclosed air space between, have also been used, with a single heating pipe in the enclosed air space, thus reducing the temperature differences either side of the two sash and in this manner eliminating the condensation and reducing the heat losses.

The heating pipes at B will tend to eliminate this trouble to a greater extent than at A, but may not entirely do so. As far as the air circulation is concerned, undue importance should not be attached to this, especially if the room is evenly heated, as this presupposes slight differences in temperature and, therefore, in the weight of the air at different levels. The level of the coils at A and B is the same and near the roof. The air below the coils must be heavier and colder than above the coils and the hotter and lighter air will not move down of itself.

If more surface is placed at the roof level than required for the glass and roof losses, the only way circulation can be produced is by moving belts and revolving machinery, which is generally the case. When the machinery stops, the air near the roof is raised in temperature and the roof transmission increases accordingly. If the roof coils are designed to counteract the radiation of the roof and the roof proper and glass are compared, it will undoubtedly be found that though the glass has a higher rate, the larger area of the roof would cause a cooling effect nearly the same or greater, especially if double glass were used.

As to whether direct steam or a blower system is better for a building of tight construction intermittently heated, this would depend largely on whether exhaust steam were available, also its temperature, pressure and quantity. With a surplus of exhaust steam at very low pressure, the blower would be at a disadvantage, if the building were of large area, as those of saw-tooth construction usually are. This is due mainly to the low specific heat of the air (0.24) and the attendant loss in temperature due to the radiation of ducts. The low height of the saw-tooth type, comparatively, and the fact that this construction is mainly for the purpose of obtaining light requires the elimination of overhead ducts, and underground ducts are very expensive, with high radiation losses.

If outside air is used, the operating cost is very high in extreme weather and ducts have to be provided if recirculation is contemplated. The low specific heat means that, with a very small B. T. U. loss in transmission, a large temperature drop occurs, the large duct area being an additional factor. Lower temperatures mean larger volumes and increased size of apparatus.

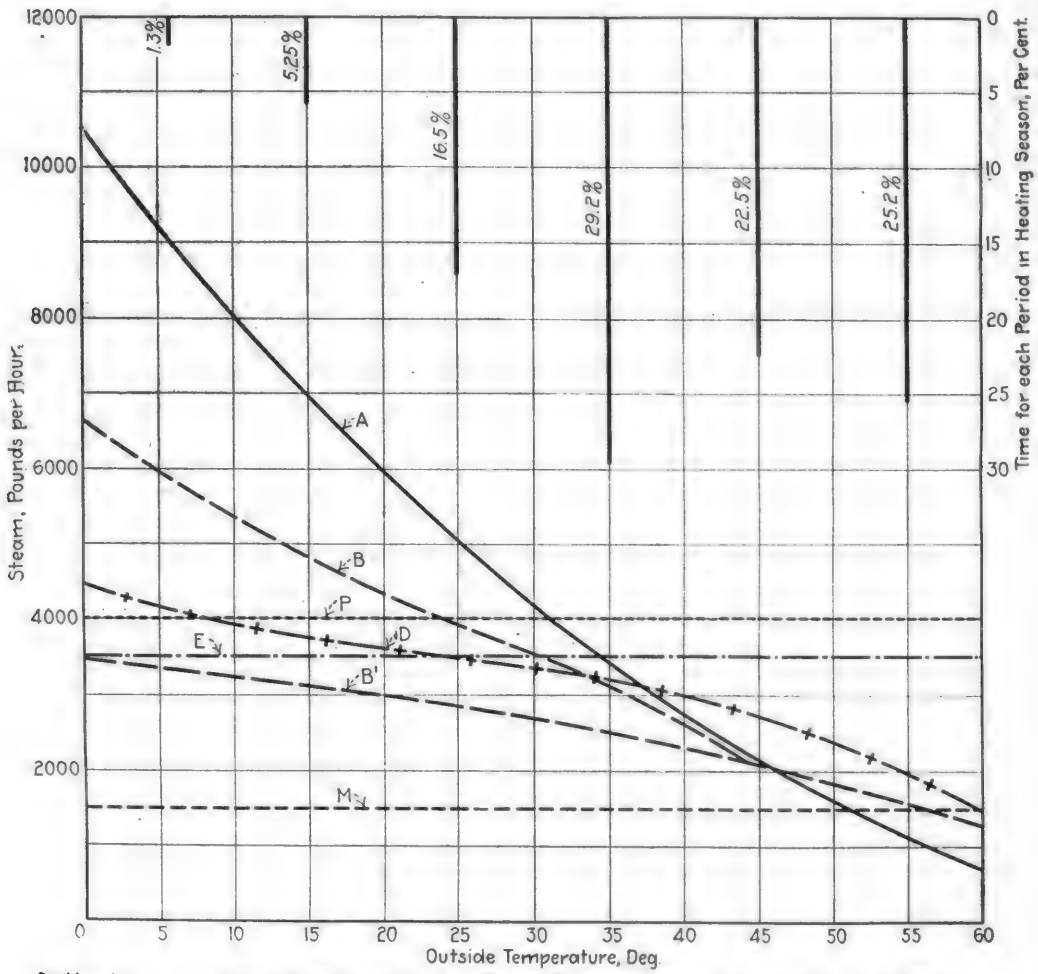
The operating cost of direct radiation as against a blower system of circulation would be about the same for the entire season, but the fan system would have an exceedingly higher peak in extreme weather, increasing the necessary boiler capacity.

In moderate weather the power to operate the fan would furnish sufficient exhaust steam, in many cases, to make the heating system a live steam proposition.

All blower men guarantee their apparatus for temperature requirements under conditions of continuous operation in extreme weather, and if operated intermittently the apparatus would have to be increased in size and cost, which would also add to the operating expense.

Fig. 1 is a series of curves giving the relation of operating expense of a fan system, a direct radiation system and a combination of the two, for different outside temperatures. In this case the medium was hot water which makes the direct radiation more flexible in temperature than low pressure steam, but the relation would hold fairly well on steam.

The combination system was recommended for high shop buildings where forced hot water was used as a heating medium and it was desired to heat with very low temperatures of water in extreme weather, without an excessively large apparatus. In this case, one-half of the direct radiation was used to counteract the wall and glass losses and the fan recirculated the cubic contents and was about one-half the size that would be required if only hot air were used. The air was circulated from the roof to the floor level, reducing the temperature of the roof to that of the floor and



A = Hourly consumption, Hot Blast System, Water or Steam
B' = Direct Radiation of Combination System, Hot Water
B = Blower and Direct Radiation on Combination System
D = Direct Radiation only on Hot Water.
E = Steam to operate fan on Hot Blast System
M = Motion to operate fan on Hot Blast System from Main Engine
P = Direct Radiation on Steam

FIG. 1.—RELATION OF OPERATING EXPENSE OF VARIOUS HEATING SYSTEMS FOR DIFFERENT OUTSIDE TEMPERATURES.

thus decreasing the roof radiation. The fans were not operated nights or when the weather was above 30° F. outside.

The maximum water temperature was never over 200° F. The curves show the high peak of the blower system in extreme weather. For intermittent heating as described, direct steam would be the more satisfactory and cheaper, as the pressure could be more easily and quickly varied.

Elbert Hubbard on Trade Papers.

Editor's Note.—This is the first of a series of essays by this inimitable writer that will appear in THE HEATING AND VENTILATING MAGAZINE. *Fra Elbertus here discourses on the subject of subscribing for, paying for, reading and studying your trade paper.*

In these strenuous days, ists and isms have to bear the scrutiny of reason and the test of common sense and truth. Sufficiality gives way to specialty. The smatterer, the literary hobo of commercialism is succeeded by the business man whose knowledge is based on scientific principles, those of intimate knowledge of cause, effect and values.

And, paradoxical though it may appear, it is this very specialization, this narrowing down to defined, indelible issues that gives us a wider outlook and a fuller education. Provincialism retards growth. We need to become universalists and to think and act imperially.

"I can't get San Francisco to answer," said a Chicago telegraph operator on the morning of April 16, 1906. "Well, try again," was the answer, "and then if no reply comes call up New York and tell them to call London, and have London call Yokohama, and Yokohama will call San Francisco."

And in half an hour the dread news came.

"Mine and thine," was the yardstick of old-time business relationship—with the thumb covering an inch at the "thine" end! "Ours" is now becoming the standard of dealing, and business men know this as the foundation of all successful business. And so, to seek knowledge anent the goods you sell or the service you offer, is not only profitable monetarily but morally. You become part of the commodities you deal in, they mirror your character and personality.

Everything must be "all wool and a yard wide." Also, he must know why it is all wool and a yard wide, and impart that information to the prospective buyer. So knowledge, therefore, is not simply a question of absorption—it grows by giving. And this growth by giving, presumes and proves co-operation. No man can lay claim to education without co-operation. No man can hope for business success unless he gets a grip of that truth.

In the old days business men cut each other's throats. Later they cut prices. Then they cut acquaintance. Now they co-operate. The inane competition, born of selfish rivalry, which has only one object—success through the failure and elimination of a competitor—is now almost nonexistent.

The competition that obtains nowadays is that of friendly rivalry, based on trustfulness, which seeks to merit success. It is emulation; a noble effort to obtain the highest excellence and give the highest good by sustained effort and applied intelligence.

The one-price system and the fulfillment of "promises" have contributed largely to this desirable condition and friendly feeling between business men and business houses. All this has been the result of education. The truths of fraternity and the square deal have been assimilated until they have become the life-blood of industrial and commercial activity.

It is to meet the requirements of these new economic conditions, this thirst for special information on specific subjects, that we have offered to us technical and commercial courses by various schools and colleges throughout the United States. And thousands have benefited thereby. But if I were asked what I consider the chief medium of instruction and helpfulness for the business man of today, I should unhesitatinly say his Trade, Technical or Class Paper.

The very fact of being a subscriber and paying for his specific paper, is an education in itself. It tokens a healthful interest in what others are doing in the same line of business, and is bound to make a man a better dealer and a better citizen. Getting together is the big slogan of today.

Any individual who is alone, whether he realizes it or not, is on the slide to limbus. We succeed only as we move with other people. The man who subscribes to, and reads his trade paper, is en rapport with men and things. He is no atrophied anthropoid or paleolithic anthropophagi, with head grown beneath his shoulders.

He is a glowing coal, a live wire; he is in the line of evolution. The genesis of all correspondence schools and courses was a mining paper, run in a country district. Now that great institution gives instruction to millions of students all over the world.

And the good trade, technical and specialized papers published in America today are fostering and nurturing this knowledge getting idea. They secure knowledge and give it out. And knowledge is power. Thousands of busy business men and advertisers look to the papers in their field for inspiration and encouragment and they are not disappointed. Their specialized paper becomes their encyclopedia.

It is a mine from which they quarry the four-space stones upon which to build the fabric of commercial success. Nuggets of wisdom and jewels of thought are added to their stock in trade.

These have been tried in the fire of experience and by the acid test of practicability. Experts and specialists fill the trade paper with contributions of inestimable value to the reader. The well-written columns are filled with advice, information and suggestions. Is it any cause for wonder, therefore, that the subscriber is optimistic, prosperous, respected?

"As iron sharpeneth iron so does man the countenance of his friend." And the trade papes gives to its readers a clearer vision, a broader outlook, a bigger heart. It keeps him from becoming mean, small, petty, pestiferous with bats in his belfry. It enables him to get a better knowledge of his goods and service. It shows him how to handle these goods and render that service to the mutual advantage of himself and his customer.

It teaches him that all men are brethren, that nothing goes but truth. That variety in form, color and expression are all in Nature's scheme. And realizing these things he becomes a better salesman, a better craftsman, a better man. His "techiness" gives place to tolerance and he becomes an interested, enthused business man whose religion is to be good and whose business is his religion.

Attempt to Nullify Chicago's Theatre Ventilation Ordinance.

A determined attempt to repeal the picture theatre ventilation requirements was disclosed in a resolution introduced before the Chicago city council recently by Alderman Schaeffer, repealing the section providing for the ventilation of auditoriums and picture theatres. Alderman Schaeffer's resolution was referred to the building committee. As the council was holding its last meeting for the summer, this action meant that the resolution would not be considered by the council until fall. Alderman Schaeffer thereupon introduced an order directing department heads not to enforce the section until further action had been taken by the council.

Mayor Harrison subsequently vetoed the order, after a conference with Health Commissioner Young, so that the ordinance is still effective.

It is clear, however, that the picture theatre interests, which have an organization known as the Motion Picture Exhibitors' League, is conducting a persistent campaign for the repeal of the theatre ventilation ordinance. In an interview on the subject Health Commissioner Young stated that information had reached him that the owners have collected a fund of $10,000, to be used in fighting the enforcement of the ordinance.

When the repeal resolution was introduced in the council by Alderman Schaeffer he advocated such action on the ground that it would inflict hardship on the churches if they were required to install proper ventilation systems before the heating season arrived.

Comparative Advantages of Heating System.

A comparison of the advantages of the various heating systems for residence use, together with a resume of their strong and weak points, are contained in a readable article on "Heating and Ventilating the Country House," by Cecil F. Herington, which appears in Suburban Life.

Referring to warm air furnace heating, Mr. Herington states that a furnace is not suitable for large houses, as the horizontal pipe runs are too long and the air loses much of its heat on the way. A furnace will also carry much more dust into the house with its hot air than either steam or hot water.

"This leaves the summary of the furnace," continues the writer, "as cheap to install, simple to run, suitable for small houses not in locations exposed to high winds or much dust, likely to be uncertain in operation and requiring more cellar room than other methods."

Steam heating is sized up as "positive, costs little more than a good furnace system, can be operated economically, is suitable for any size of house, can be automatically controlled either at the boiler or by a thermostat in any room, is not easy to modify in mild weather, and requires care in operation to keep the water at proper height and steam at proper pressure, air-valves are susceptible to trouble with grit or impurities in the system and are liable to cause leakage, and the floor space for radiators is considerable."

"Hot water heating," says the author,

"costs more to install than either steam or furnace heat, but costs less to operate, takes more floor space, for radiators, has double pipes for each radiator, costs more for automatic control at the heater, is slower to heat up than steam, is more liable to have poor circulation in one or more radiators, and must never be exposed to the danger of freezing."

Referring to vacuum and vapor house heating systems the advantages and disadvantages are thus presented: "During cold weather, they can be run as a plain-pressure steam system, thus requiring radiators of only the normal steam size; during mild weather, the vacuum in operation will permit running the fire in the steam boiler practically just as low as in a hot-water system; the steam under the vacuum has a temperature as easy to graduate as hot water by simply changing the amount of vacuum; the air-valves are dispensed with, and a return pipe is run back to the vacuum-producing apparatus, thus insuring good circulation; it is just as quick to heat up as steam, and will not be seriously injured where a radiator is exposed to freezing.

On the other hand, the vacuum-producing apparatus is more liable to give trouble on account of its complication, while the essential parts are patented, making the cost of a vacuum-vapor system about equal to that of hot water, although the radiators are smaller, there is no expansion tank, and the piping is not so large. One great advantage of vapor-heating lies in the fact that the companies owning the patents on these systems are willing to design the systems free of charge and to guarantee the results which goes a great way toward insuring a house-owner of getting a heating system properly laid out.

Legal Decisions

Liability for Escape of Steam.

In a recent New Jersey case it appeared that the plaintiff rented an apartment under an agreement that steam heat would be supplied by the landlord. After putting her furniture in the apartment, preparatory to going to reside there, she came back after some days and found the place full of steam and the radiator disconnected and steam coming in from the open pipe. She was unable to live in the apartment, and had to take up her abode elsewhere; and her furniture was damaged. The landlord was held liable for the damage.—L. Pichard vs. George N. Thurber Co., New Jersey Supreme Court, 86 Atl. 953.

In another case, in New York, it was held that a landlord who negligently fails, for an unreasonable time, to repair a broken pipe connecting a radiator forming a part of the steamheating apparatus in his control, is liable for damages to a tenant's property by escaping steam, where if a third person, without the knowledge of the tenant, turns the valve, so as to cause steam to escape, but he is not liable where the tenant, after being warned not to turn the valve, turns it, and thereby causes the steam to escape. —Isaacs vs. New Haven & New York Realty Corpn., New York Appellate Division, 141 N. Y. Supp. 338.

Performance of Contract—Architects's Certificate.

A contractor agreed to erect a steam heating plant in flat houses according to plans and specifications for $2,500. The specifications provided for the removal of all the existing radiators and risers. There were 24 risers in all; the contractor removed only 16. In his action for the balance of the contract price he testified that the others were in working order. The court held that the plaintiff had not proved that his work was completed. The contract did not make the architect's certificate conclusive between the parties. The plaintiff obtained a certificate from the architect on a mere statement made to him by the plaintiff, which certificate the architect afterwards revoked. It was held that the plaintiff could not rely upon this certificate and judgment in his favor was reversed and a new trial ordered.—Rausen vs. Leonhardt Realty Co., New York Appellate Division, 140 N. Y. Supp. 493.

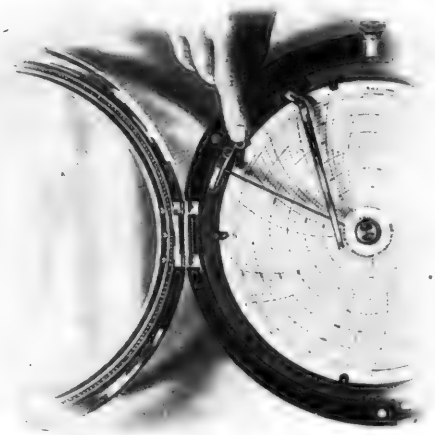
A New Improvement for Recording Instruments.

As the demand for high grade, accurate and durable recording instruments has been increasing rapidly during the past few years, the manufacturers of such instruments have endeavored to meet the many requirements, with the result that the up-to-date recording instrument has many marked improvements over the types formerly on the market.

The Industrial Instrument Company, Foxboro, Mass., has just perfected a new attachment for its records, for which patents are pending.

This attachment is called an automatic release pen lifter. It can be attached to any Foxboro improved recorder. It is a simple device, consisting of a German silver strip mounted on a special holder, which is inserted under a screw head which holds the chart disc. A slight pressure on a small

lever brings the strip up against the pen arm and lifts the pen from the chart. Friction holds it in the raised position, thus giving the operator free use of both hands for removing the used chart and supplying a new one. When the door is closed, the pen arm is automatically released and the pen returns to its marking position on the



AUTOMATIC PEN RELEASE PEN LIFTER FOR USE WITH RECORDING INSTRUMENTS.

chart. This automatic feature makes it impossible for the operator to forget and leave the instrument out of commission.

The device also does away entirely with the necessity of handling the pen arm, with possibility of affecting the adjustment due to a slip or accidental strain.

Hoffman Siphon Air Valve.

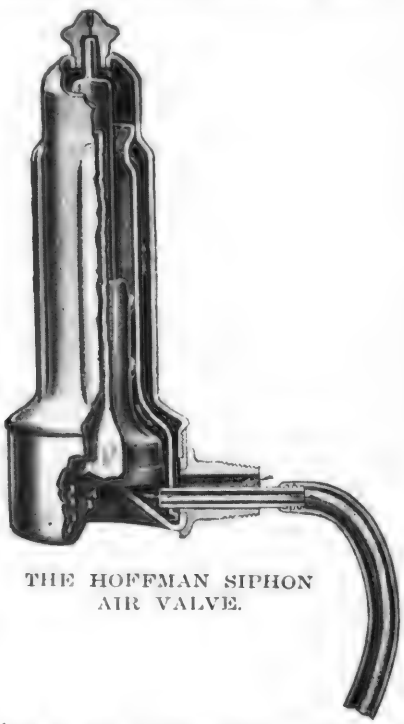
We show herewith a partial sectional cut of the Hoffman siphon air valve, which is being placed on the market by the Hoffman Specialty Co., 210 Congress St., Boston, Mass. The fact that this valve was designed and invented by George D. Hoffman, the inventor of the Norwall air valves, is substantial evidence that it is worthy of investigation on the part of the air valve buyer and user.

Its special construction features are the peculiar float and inner shell. The float is a sealed metal chamber having a flexible bottom, which is the expansible member of the valve. This flexible bottom is made of phosphor bronze, the toughest metal known. The sealed metal chamber contains a volatile or heat sensitive fluid, which vaporizes at 195° F., which means that the valve is closed tight at temperatures above 195° F., but is wide open, freely venting the hot air from the radiator, at temperatures below 195° F.

The valve is permanently adjusted at the factory, and is, therefore, an absolutely automatic valve, requiring no attention on the part of the steam fitter or the user.

The second function of the float is to take care of any sudden charge of water within the radiator. When water comes against the Hoffman siphon valve, it instantly closes, and closes tight against water leakage, but when the water drops away from the valve into the radiator, the siphon shown in the cut automatically discharges the water in the valve back into the radiator, and the valve recommences venting without the spitting of water.

When the siphon discharges water from the Hoffman siphon valve, the air passes into the valve through distinct separate passages provided for it by means of the inner shell and the four embossed channels in the outer shell, which are formed into conduits because of the glove fit between the outer and inner shell above the base.



THE HOFFMAN SIPHON AIR VALVE.

Referring to the illustration, the upward pointing arrows indicate the air channel, and the downward point arrows, the water channel. It will thus be seen that the air flows into the valve as water flows out without conflict between the air and the water. Air entering the valve cannot pass through the water in the float chamber, but must enter through the channels provided. The outlet from these channels being above the water line in the float chamber, the air passes out of the valve dry and without the slightest spit.

BADGER SELF-EQUALIZING EXPANSION JOINT.

The valve is guaranteed by the manufacturers to automatically vent any steam radiator which can be manually vented by a pet cock, and to do it without steam or water leakage through the valve. The valve is also guaranteed to be operative on any low pressure steam job.

The Hoffman siphon valve is sold exclusively through the jobbing trade. Further information concerning the valve may be had by addressing the manufacturers.

Test of a Badger Expansion Joint.

The Badger self-equalizing expansion joint is distinctively a copper joint, corrugated for strength and for taking up the changes in pipe length. The external rings fitting the corrugations are designed to add strength to the joint and distribute the change of shape, each ring forcing a part of the change to the next so that the strain is divided among many corrugations, instead of being taken by one or two. It is evident that if the changes of shape are subdivided and distributed instead of concentrated, the copper will last much longer.

How well the Badger distributing rings actually passes along the strains, equalizing them among a large number of corrugations, is shown by a recent commercial test. The conditions approximated working conditions, and the test was well conducted and the records kept in such shape as to eliminate all guess work.

Tabulated by separate tests the figures show the behavior of every corrugation—they give the distances between them before the pressure was applied, when under load, and after the load was removed. The accompanying figure shows the results graphically, the actual measurements being shown as well as the relative changes of shape.

The joint was a large one, 20-in. in diameter and 23¼ ins. long, between flanges. It had seven corrugations or depressions. In order to have the joint heated nearly to working temperature, it was filled with steam at about 5 lbs. pressure. For testing, the joint was secured at one flange and shortened the desired amount by bolts. In this manner the joint was shortened just as it would be when squeezed together by the increase in length of two lines of pipe.

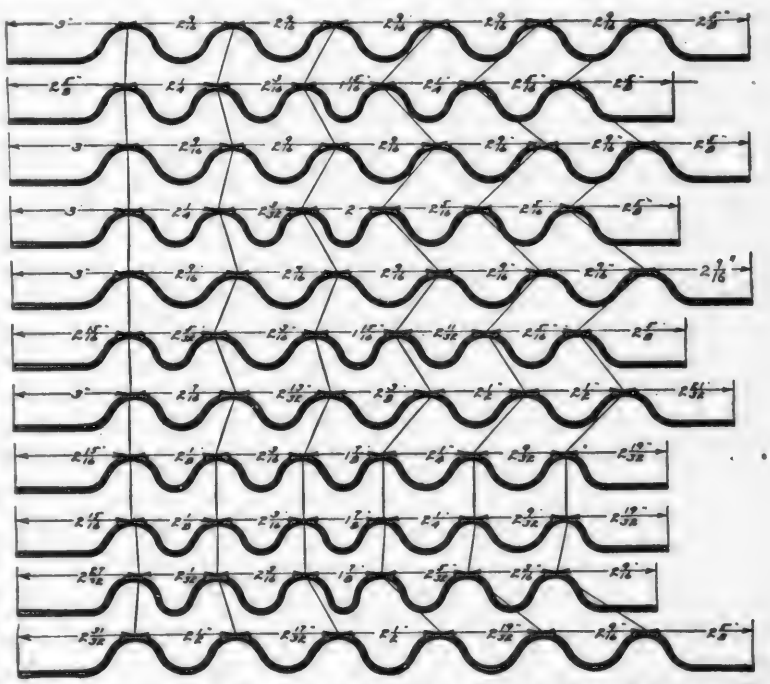


CHART SHOWING MEASUREMENTS AND RELATIVE CHANGES OF SHAPE OF BADGER. EXPANSION JOINT UNDER TEST.

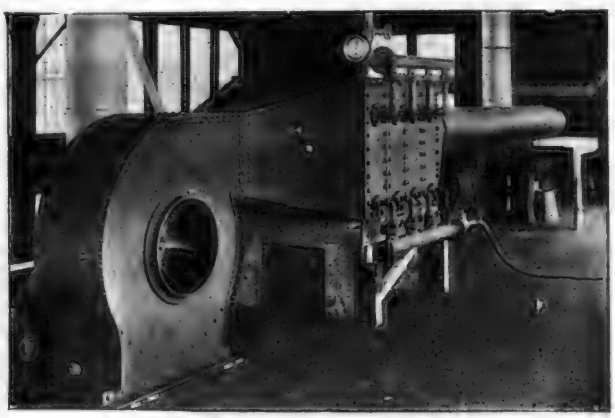
In the first test the joint was shortened two inches. The individual corrugations contracted, those in the middle taking most of the change of shape but every one helping. While the tests gave different percentages of change at a given corrugation the differences were not great, that is, under repeated test the change was nearly uniform.

When the tests had been completed the distances between corrugations were measured and compared with the original measurement. The permanent change was so slight, being only one or two 32ds of an inch, as to show the ductility of the copper.

The test shows the remarkable division of work among the rings. It also shows that the strain on an individual ring is very small, even when the aggregate is considerable. In every case the end rings contracted less than the center rings.

GREEN'S CONICAL FLOW FANS, a new fan or blower of novel design, which, it is stated, has been perfected after six years of research and experiment, is described in a leaflet issued by the Green Fuel Economizer Co., of Matteawan, N. Y. This fan differs from either centrifugal or axial flow fans in that the air enters and passes through the fan wheel and through the diffusor or stationary housing obliquely to the shaft, so that the lines of flow form substantially a cone co-axial with the shaft. It is claimed that this construction results in large air-handling capacity with a given diameter of wheel, permits high speeds and is efficient in producing pressure. In other words, the volumetric capacity and the ability to run at high speeds possessed by the ordinary axial-flow or disk fan are combined with the power to produce moderately high pressures, such as are required in heating and ventilating work, mechanical draft, etc. The object of attaining higher speeds is to permit of connecting the fan directly to standard-speed electric motors and steam turbines, thereby eliminating belts, gears, or chains. For example, it is stated that a conical flow fan, such as is illustrated in the leaflet when running at 1,800 r. p. m., gives the same pressure and volume, with a better efficiency, than do standard steel-plate and multi-blade fans recommended by the builders for the same rated capacity, but running at speeds of 565 to 695 r. p. m. The fact that no part of the conical flow fan greatly exceeds the diameter of the wheel and that air is propelled forward along the line of the shaft without the right angle turn encountered in centrifugal fans, together with the fact that the driving motor can be directly connected, greatly reduce the size and space requirements, as compared with centrifugal fans. This is particularly noticeable where the conical flow fan is to blow into a hot blast heater, in which case, the fan and motor, together occupy less space than

GREEN'S CONICAL-FLOW FAN DIRECTLY CONNECTED TO FOUR-SECTION 3 FT. x 3 FT. HOT BLAST HEATER FOR TEST, SHOWING SAVING IN SPACE.



STEEL PLATE FAN DIRECTLY CONNECTED TO A FOUR-SECTION 3 FT. X 3 FT. HOT-BLAST HEATER.

does the "expansion piece" ordinarily used for connecting the centrifugal fan to the heater, or about one-third of the space required by the centrifugal fan, motor and connection. This fan is also said to produce less "air noise" than do centrifugal fans, due to the omission of the "cut-off." The leaflet, which gives a table of sizes, capacities, pressures, speeds and motor horse powers, should prove of particular interest to architects and others requiring fans to be installed in limited space, or wishing to avoid the complication and nuisance of belts and gears.

GREEN'S CONICAL-FLOW FAN.

Programme of Trade Press Convention.

The completed programme for the eighth annual convention of the Federation of Trade Press Associations, to be held at the Hotel Astor, New York, September 18-20, is calculated to claim the interest of both reader and advertiser, as well as editor and publisher, for it treats of every aspect of trade paper activity. Different symposiums have been arranged, one for the editors, one for the publishers, one for the circulation departments and one for the advertising departments. In addition to these symposiums, which will each be addressed by from six to eight speakers, there will be a "Big Business Meeting," devoted to the inside stories of the big trade paper publishing successes. This as well as the "Inspirational Mass Meeting" on Friday afternoon will be of general interest.

An interesting feature of the advertising symposium will be a demonstration on how to sell advertising space in a trade paper. The seller will be represented by H. M. Swetland, of the Automobile, New York, and the buyer, by John A. Hill, of the Hill Publishing Co., New York.

The convention will conclude with a banquet at the Hotel Astor Friday night, when Postmaster-General Albert S. Burleson, Secretary of Commerce William C. Redfield and John Kendrick Bangs will be among the speakers. William H. Ukers, 79 Wall St., New York, is chairman of the committee on arrangements.

International Engineering Congress in 1915.

The committee of management of the International Engineering Congress, announces that Col. George W. Goethals, chairman of the Isthmian Canal Commission and chief engineer of the Panama Canal, has consented to accept the honorary presidency of the congress and will preside in person over the general sessions to be held in San Francisco, September 20-25, 1915.

The Efficiency Society.

An outline of meetings of the Efficiency Society for 1913-1914 include a conference in December in New York when progress in scientific management will be discussed, including financing and business credit systems.

In January the society will hold a three days' conference on profit-making industrial enterprises. At the same time an efficiency exhibition will be held at the Grand Central Palace, New York. The February meeting will take up elements of costs while the March meeting will consider mechanical appliances, including freight handling, shipping, packing, cartage and transportation. The subject for April is efficiency in the use of supplies, including storage.

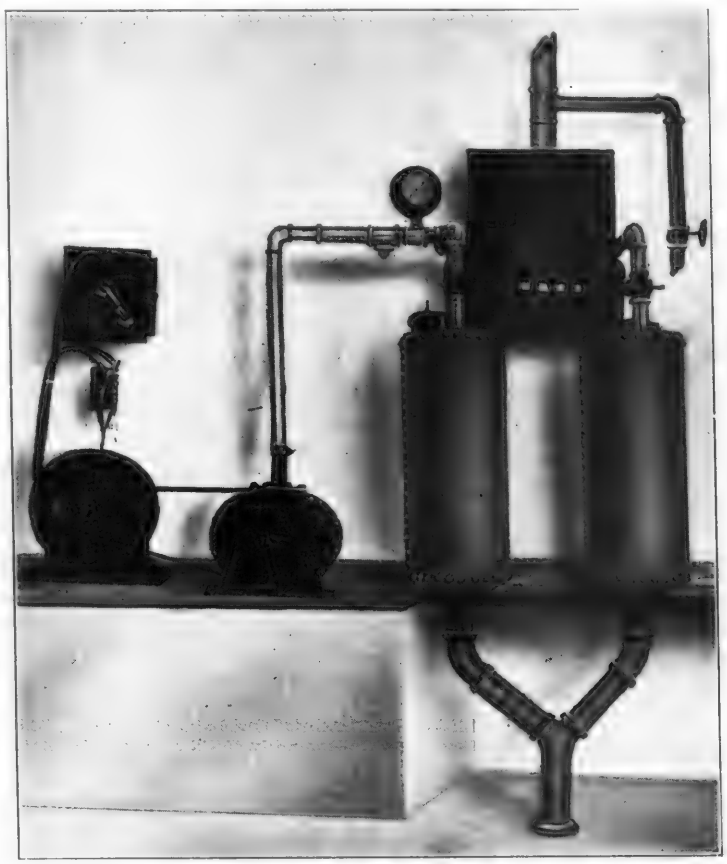
The society has adopted the magazine size (6x9 in.) for its monthly publication which contains, in addition to society notes, regular contributions from its members on various phases of efficiency.

A new and revised edition of Prof. Jas. D. Hoffman's "Handbook for Heating and Ventilating Engineers" has just been published by the McGraw-Hill Book Co., New York, and may be had at $3.50 through our book department.

Modern Vacuum Cleaning Apparatus

II—Dunn's Improved Vacuum Systems.

Immediate disposal of the dust and dirt by sending it directly to the sewer is one of the principal points emphasized in the operation of the Dunn improved vacuum system. All sweepings are saturated and carried off to the sewer while the plan is in operation, without passing through the pump and without requiring handling at any time. As a result of this arrangement no tanks, bags, screens or other obstruction to the passage of all the dirt to the sewer are used with this system.

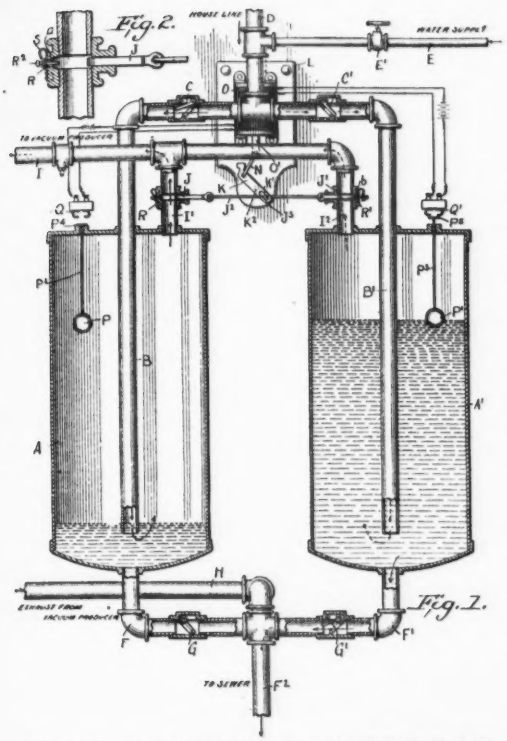


DUNN IMPROVED VACUUM CLEANING SYSTEM.

The plant, a typical view of which is shown in the accompanying illustration, is composed of a motor and a starter, a rotary vacuum pump running at a moderate speed, a vacuum gauge, two tanks, automatic electrical apparatus and piping connections. Ordinarily the plant is mounted on a concrete foundation, in a compact unit, but if conditions require it, the tanks and other accessories may be placed at any distance from the motor without affecting the plant's efficiency.

After starting the motor and turning on a small quantity of water, a vacuum is produced in one of the tanks and through a system of piping to the cleaning implement in use. The dust and dirt collected by the implement is saturated as it approaches the plant and in this saturated condition enters the bottom of a body of water in the tank.

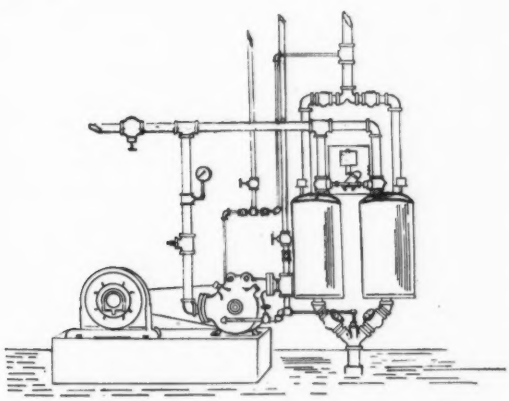
When the accumulating dirt and water reach a certain level, a valve is automatically operated which closes the tank's communication with the vacuum pump and allows its contents to flow off to the sewer by gravity. The mechanism for operating the valve is rather unique and includes a float which, on rising with the water, makes a positive electrical contact, as shown in Fig. 2. In this illustration the tank is shown as about to discharge and the other tank as



DETAIL OF INTERIOR CONSTRUCTION, DUNN VACUUM MACHINE.

about to become operative. The electrical contact causes the core of the magnet at O' to rise, making the lever K turn over, which action opens one valve and closes the other. In this way the tanks alternately partly fill and empty their collections of water and sweepings.

This system was designed and is marketed by E. B. Dunn, 108-110 West 34th Street, New York. Mr. Dunn is widely known as formerly in charge of the New York station of the United States Weather Bureau.



SECTIONAL ELEVATION OF DUNN VACUUM CLEANING SYSTEM.

Trade Literature

CHICAGO AUTOMATIC ELECTRIC CONDENSATION PUMPS, including the latest models of this apparatus, are the subject of Catalogue D, just issued by the Chicago Pump Co., Chicago, Ill. This catalogue will be of interest to prospective buyers, as it describes many new additions to this pump which has already been widely adopted, as shown by the numerous commendatory letters included in the catalogue. Among the advantages mentioned for the pump are that it saves the digging of boiler pits and cuts the coal bills from 20 per cent to 50 per cent. It is especially recommended for use where indirect coils or radiators are placed below water level in boiler, where heating return pipes are below the water level in boiler, where there is a difficulty in maintaining the proper temperature during the winter months, where the steam heating apparatus is defective or too small, where, through settling of foundations, water pockets are formed in the piping, and, finally, where inefficient janitor service causes the building to be insufficiently heated. Size 6x9 in. (standard). Pp. 28.

BEACH-RUSS VACUUM PUMPS for Return Line Vacuum Heating Systems, made by the Beach-Russ Co., 220 Broadway, New York, have recently been placed on the market and are illustrated and described in recently-published circular matter. The pump is electrically driven, of rotary type, and the manufacturers state that it is quite noiseless in operation, in addition to being simple in construction. It is made of Monel metal. The Beach-Russ Company has been making vacuum pumps for the past 18 years, which is assurance that the mechanical features of the company's new product have been well taken care of. The company announces that W. S. Ransom, who has had a long experience in this line, is now connected with its vacuum heating pump department. The circular include data on five sizes of pumps, having capacities ranging from 3,000 to 40,000 sq. ft. of radiation.

PIPING FOR ECONOMY IN STEAM PLANTS, by Lucius B. Andrus, giving a description of the steam plant of the Indiana & Michigan Electric Company, at South Bend, Ind., is the subject of an illustrated article in the *Valve World* for August, 1913, the monthly periodical of Crane Co., Chicago.

MOLINE SYSTEM OF HEATING, described as a system of noiseless heating by vapor, designed to operate naturally without pumps, traps or automatic radiator valves, is the subject of a new and elaborate catalogue issued by the Moline Vacuum Vapor Heating Co., Moline, Ill. Size 7½x10½ in. Pp. 32.

SECTIONS B AND C OF THE COCHRANE SEPARATOR CATALOGUE have now been published by

the Harrison Safety Boiler Works, 3189 North 17th St., Philadelphia, Pa. Section B is devoted to receiver separators for installation in the steam lines to steam engines and turbines. It describes high-pressure steam separators equipped with wells or receivers of large capacity for the purpose not only of storing exceptional amounts of water, but also to serve as a reservoir for the storage of steam between the intervals of opening of the engine admission valve. A chart is given by which the most economical diameter of steam piping may be ascertained, assuming coal at $3.00 per ton, and uniform flow, as where receiver separators of large capacity are installed.

Section C is devoted to oil separators. The introduction to this pamphlet contains interesting information regarding the removal of cylinder oil from exhaust steam for the purpose of rendering the latter suitable for heating water by actual contact in open heaters or for use in heating or drying systems where the condensate is to be employed for boiler feeding. The pamphlet also discusses various applications of separators and the manner of using them, as in connection with heating systems, paper mills, textile mills, ice plants, etc. Size 6x9 in. (standard). Section B, 32 pages, Section C, 20 pages.

IMPROVED METHODS OF CONNECTING SMALL TURBINES IN STEAM POWER PLANTS and Exhaust Heating and Drying Systems, is the subject of a booklet distributed by the De Laval Steam Turbine Co., of Trenton, N. J., in which are described several methods of connecting small turbines for drawing auxiliaries in large steam power plants, also in connection with exhaust steam heating and drying systems in isolated plants. One arrangement particularly recommended for heating systems is a low-pressure turbine to be installed in connection with an existing engine, the turbine being so connected up that it can supply steam at atmospheric pressure for heating purposes during the winter, but during the summer operate upon low-pressure steam from the engine, exhausting to a condenser, giving the maximum overall thermal efficiency at all times.

BRISTOL'S ELECTRIC RESISTANCE THERMOMETERS, Model 162, are the subject of a new bulletin (Bulletin 175) issued by the makers, The Bristol Co., Waterbury, Conn. The bulletin contains two illustrations and brief descriptive matter about a new line of electrical resistance thermometers which the company is nearly ready to place on the market. Another bulletin (Bulletin 176) is devoted to Wm. H. Bristol electric pyrometers, a combination indicating and recording unit.

Bristol's wet and dry bulb recording thermometers for computing the degree of humidity or percentage of moisture in the atmosphere either outdoors or indoors are the subject of a third bulletin (Bulletin 178). These instruments are recommended as especially valuable for drying rooms and dry kilns. The bulletin gives two illustrations and some preliminary description showing their use for recording wet and dry bulb temperatures on the same chart, on the basis of which the humidity of the atmosphere can be computed. All of the bulletins are of the company's same standard size (7x10 in.), punched for binding.

COLLINS AIR LINE SYSTEM, designed and sold by Emmons Collins, 35 South Dearborn St., Chicago, is a new system of heating described and illustrated in circulars showing a typical installation. Mr. Collins was formerly connected with the Bishop-Babcock-Becker Co., Cleveland, O., and later with the Consolidated Engineering Co., of Chicago.

THE TRUTH ABOUT VAPOR, by A. P. Broomell, is a newly-issued treaties published by the Vapor Heating Co., Philadelphia, Pa., tracing the development of this method of heating. Views are included of specialties used in the Broomell system of vapor heating, which is sold by this company. Size 3x8 in. Pp. 16.

BUFFALO ELECTRIC FANS, made by the Buffalo Forge Co., Buffalo, N. Y., are described and illustrated in the company's catalogue No. 181-E, prepared for the convenience of engineers and others wishing data on motor-driven blowers and exhause fans for all purposes. It is pointed out that geater care is required in the installation of direct-connected centrifugal blowers than when driven by belt, to avoid overloading of the motors, which may be done by a small increase in speed. The catalogue shows a large range of standard connections, while for special requirements the company states that it is prepared to make designs and fill orders for "made-to-order" units. Size 6 x 9 in. (standard). Pp. 32.

National Tube Co., Pittsburgh, Pa., announces that commencing Aug. 1, 1913, it will enter the electrical conduit field. The company has contracted with the National Metal Molding Company and the Safety-Armorite Conduit Company, both of Pittsburg, to manufacture and sell this product as the agents of the National Tube Company, under their various brands. The company will sell this product on the "Pittsburg basing discount" plan, in the same manner as all wrought-iron pipe for other purposes has been sold for the past 13 years.

Placing Air Pipes to Get Maximum Heat.

It is improbable that there will be any large difference of opinion among those experienced in the trade as to the location of registers in houses in which furnace heating equipment is installed, says the Building Age. The majority of experienced furnace-men favor the shortest pipe from the furnace and to have the register placed near one of the inside rather than near one of the outside walls. It has been given as the experience of successful, observing furnace-men that registers near the outer walls are not as efficient as if placed contiguous to the interior walls of a room.

With any system of heating the warm air at the ceiling on approaching the outer wall, strikes a cooler surface and falls along the wall, increasing in velocity as it follows down the cooler wall until it drops with some positiveness near the floor. Consequenty when a warm-air register is put in the path of these down currents the warm air that should rise from it is retarded and in some instances the outflow is entirely stopped. This leads to a down current of cool air through the pipes of the furnace, if the furnace is not adequately supplied with air from some other point.

It has been observed that the positions of a radiator and a register are selected from directly opposite points of view. Radiators as a rule are placed near windows, where the greatest amount of cold air falls, so that they can warm it as it falls, or drive conflicting currents of warm air against it, while the radiator proper sends its heat into the room.

Circular Letter on the Eight-Hour Law.

Under date of July 12, 1913, the Treasury Department has issued a circular letter through the office of the Supervising Architect, calling the attention of bidders and others concerned to the fact that the so-called eight-hour law approved June 19, 1912, does not repeal the eight-hour law approved August 1, 1892. Text of the two laws is given, together with opinions rendered by the Attorney-General and the Solicitor of the Treasury. The circular is issued for reference purposes in order to avoid unnecessary correspondence regarding the points answered therein.

Standard Steam Specialty Co., New York, manufacturer of the Utility steam specialties, announces that it is now represented in Minneapolis, Minn., by Morgan & Gerrish Co.; in Denver, Colo., by the Vaughan Machinery Co.; and in Cleveland, O., by A. K. Park.

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MONASH NOISELESS SYSTEM OF VACUUM HEATING

SILENCE EFFICIENCY ECONOMY

Used with entire success in HOSPITALS, HOTELS, CLUBS, THEATRES, FACTORIES, SCHOOLS, COLLEGES, OFFICE BUILDINGS and PUBLIC INSTITUTIONS where **ELIMINATION OF NOISE** from the heating plant is desired.

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